15/16. Source Control or Remediation of Mine Wastes: Low Cost/Low Maintenance Methods

FIRMS DEVELOP BIOLOGICAL PROCESSES FOR CLEANING MINING WASTES, SITES
Anon.
HazTECH News, Vol 13 No 15/16, p 118, Aug 13/27, 1998

MSE Technology Applications, Inc. of Butte, Montana, has developed several biological treatment processes for remediating mining wastes and contaminated mining sites under EPA's mine waste technology program. The MSE processes use indigenous microbes that are taken from the site, cultured and augmented by Pintail Systems, Inc., and applied either in situ or in external bioreactors to deal with cyanide, arsenic, copper, mercury, cadmium, nickel, and zinc contamination. MSE and Pintail have conducted a successful, brief field demonstration at the Echo Bay (McCoy/Cover) mine site near Battle Mountain, Nevada, and a long-term treatment of acid mine drainage at the abandoned Lilly/Orphan Boy Mine. The biological treatments have been developed with federal funding and will be available for public use after the final report has been published, which is expected to occur in 1999. Contact: Creighton Barry, MSE, (406) 494-7268, fax (406) 494-7230, mseta@buttenet.com.

FIRM MARKETS CALCIUM POLYSULFIDE FOR METALS PRECIPITATION, FIXATION
Anon.
HazTECH News, Vol 14 No 10/11, p 72-73, June 10/30 1999

Best Sulfur Products of Fresno, California, is marketing a calcium polysulfide solution (called CASCADE(TM) or SoilMend(TM) depending on its intended application) for fixating uranium and chromium in soils in situ as well as for precipitating heavy metals and treating cyanide in water. The reagent can be mixed with soil for a landfarming-type treatment. It has also been used to stabilize metals in recirculated ground water at a wood treating site, transforming Cr(VI) to Cr(III) at a rapid rate. The reagent is in use at a uranium tailings site in Colorado, where it has been applied to immobilize molybdenum and uranium that present a threat to ground water. Contact: Roy Hardison, (800) 447-5826 or (559) 485-0114.

STABILIZATION CHEMISTRY TO BE USED FOR WASTE CLEANUP AT FERNALD SITE
Anon.
HazTECH News, 14:1&2, p 1-2, Jan 28/Feb 11 1999

A $16 million contract has been awarded to Rocky Mountain Remediation Services, LLC, Golden, Colorado, to use its proprietary chemical stabilization technology, Envirobond(TM), at DOE's Fernald site on uranium production residues. The company has completed a SITE demonstration for EPA in Ohio, but the results of the evaluation are not yet available. The technology uses a reagent containing a phosphate chain with oxygen sites that bind metal ions at ambient temperatures. It has been used at a mining site to immobilize lead, arsenic, mercury, and zinc in mining wastes. Other potential uses include placing the reagent in the treatment zone of a permeable reactive barrier to collect and stabilize metals in ground water or sprinkling the solution onto metal-contaminated soil piles and allowing it to leach through and react with metals. Contact: Richard Jensen, RMRS, (303) 215-6685; fax, (303) 215-6785.

SELF SEALING/SELF HEALING ECOBARRIER MEETS KOREAN LANDFILL LINER STANDARDS

Anon.

HazTech News, Vol 13 No 12, p 93, 2 Jul 1998

An innovative containment technology known as Ecobarrier, developed by Water Technology International, a subsidiary of Conor Pacific Environmental Technologies, Inc., has been recently demonstrated in the field at the Sudokwon municipal landfill in South Korea. Ecobarrier is constructed by layering two materials that react to create an insoluble precipitate, forming an impermeable barrier and preventing passage of liquids. It is described as "self healing" because if the seal between the two reactive parent materials is penetrated or broken, the reactive materials will contact each other and form a new seal. A variety of reactive materials can be used to form the Ecobarrier, but the technology is particularly economical for mine tailings because the wastes themselves can serve as a set of reactive materials. Conor Pacific seeks opportunities to work with firms interested in field application of the Ecobarrier to mining or other wastes management as well as to ground water containment. Contact: Rob Booth, Tel: (905) 336-4689; Fax: (905) 336-8913.

BIOLOGICAL TREATMENTS: AUSTRALIAN BUGS MUNCH GOLD TAILINGS

Anon.

Waste Treatment Technology News, Vol 13 No 8, 1 May 1998

The richness of Australia's unique biodiversity has been highlighted with the discovery by scientists from CSIRO-Australia's national science and technology enterprise-and BacTech Pty Ltd. (Perth, Australia), a mining biotechnology firm, of indigenous microbes capable of devouring toxic effluent from gold extraction. The discovery could also pave the way for a major advance in "clean green" processing of minerals such as gold, copper, nickel, and zinc from sulphide ores. Peter Franzmann and Matthew Stott of CSIRO Land and Water and CSIRO Minerals have identified several new species of native microbes able to break down the thiocyanate formed from the cyanide used to extract gold. This discovery has led to the development of a process for cleansing the waste streams from inland gold mines, where clean water is often a scarce and costly commodity. Based on a process used by the Homestake mine in the U.S., this system uses uniquely Australian organisms adapted to the local conditions.

MOLYBDENUM TREATMENT AT BRENDA MINES

Aube, B.C. (Noranda Inc., Pointe Claire, PQ); J. Stroiazzo (Noranda Inc., Westbank, BC)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1113-1120, ©2000

Brenda Mines, located 22 km northwest of Peachland in British Columbia was an open pit copper-molybdenum mine which closed in 1990 after 20 years of operation. The primary concern in Brenda's tailings and waste rock drainage is molybdenum at a concentration of approximately 3 mg/L. The mine drainage is alkaline and contains little or none of the typically problematic heavy metals. Given that the waters downstream are used for municipal water supply and some irrigation, a discharge limit of 0.25 mg/L molybdenum was imposed with specific water quality guidelines in the receiving creek. A review of all existing and potential molybdenum removal methods was undertaken prior to mine closure. The chosen process is a two-step iron co-precipitation with clarification and sand filtration at a slightly acidic pH. A 4,000 usgpm (912 m3/h) treatment plant was constructed and commissioned in 1998, at a cost of $10.5M. The successful removal of molybdenum from the drainage water is explained.

ENVIRONMENTAL IMPACTS OF MINING ACTIVITIES: EMPHASIS ON MITIGATION AND REMEDIAL MEASURES
Azcue, Jose M. (ed.)
Springer Verlag. ISBN: 3540643443, 1998

BACTERIAL REDUCTION OF SOLUBLE URANIUM: THE FIRST STEP OF IN SITU IMMOBILIZATION OF URANIUM
Barton, L.L. (Univ. of New Mexico, Albuquerque); K. Choudhury; B.M. Thomson; K. Steenhoudt; A.R. Groffman
Radioactive Waste Management & Environmental Restoration, Vol 20 No 2-3, p 141-151, 1996

The problem of uranium mobility in groundwater can be addressed by converting the water-soluble uranium ion to a less soluble ion in order to control its distribution. This study of the bacterial bioconversion of uranyl, U(VI) to uranite, U(I) used six strains of bacteria individually or in cultures form sludge or uranium mill tailing sites. In pure cultures, 82-92% of U(V) was reduced, while 45-99% of the added uranium was transformed by the bacteria present in groundwater. Uranium reduction by bacteria was not affected by the osyanions of selenium and vanadium, while the reduction process was inhibited by arsenic and molybdenum at 1.0 mM.

LONG TERM PERFORMANCE OF THE NICKEL RIM REACTIVE BARRIER: A SUMMARY
Benner, S.; D. Blowes; C. Ptacek, Univ. of Waterloo, Waterloo, ON, Canada
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1221-1226, ©2000

A full-scale reactive barrier was installed into an aquifer impacted by acid mine drainage in August 1995 at the Nickel Rim mine site near Sudbury, ON. The primary mechanism of water quality improvement seems to be bacterially mediated sulfate reduction and metal sulfide precipitation. Dramatic changes in the ground-water chemistry have been observed, with up to 90% decline in Fe (from >18 to <2 mmol L-1) and increases in alkalinity from <1 to >10 mmol L-1 (as CaCO3). Over a 3-year period, the rate of Fe removal declined by approximately 35%. Primary controls on barrier performance are organic carbon reactivity, ground-water temperature, and variable residence time within the barrier.

PERMEABLE REACTIVE BARRIERS FOR THE TREATMENT OF MINE TAILINGS DRAINAGE WATER
Blowes, D.W.; C.J. Ptacek; S.G. Benner; K.R. Waybrant; J.G. Bain, Waterloo Univ., ON
Uranium Mining and Hydrogeology II. Vol 2: Supplements
GeoCongress, Vol 5 Pt 2, p 113-120, 1998

Investigators found that permeable reactive barriers, designed to induce bacterially mediated sulfate reduction, promote the precipitation of sparingly soluble sulfide minerals. This, in turn, results in the attenuation of dissolved metals, including Fe, Ni, Zn, Cd, Co, and Cu. Their findings indicate that permeable reactive barriers have the potential to prevent the discharge of acidic, metal-rich waters from mine wastes. Laboratory batch and column studies resulted in decreases in the concentrations of sulfate iron and other metal. A pilot-scale field study, conducted in an aquifer containing a plume of mine waste-impacted ground water, induced sulfate reduction and metal-sulfide precipitation. It also

removed iron and produced enough alkalinity to remove the acid generating potential of the plume water. Investigators installed a full-scale permeable reactive barrier in August 1995 and found that when water entering the barrier was compared to treated water exiting the barrier, sulfate concentrations had decreased from 2,400-4,500 mg/L to 200-3,600 mg/L; iron concentrations had decreased from 250-1,300 mg/L to 1.0-40 mg/L; and the ground water had been transformed from acid producing to acid consuming.

MITIGATION OF ACID ROCK DRAINAGE AT THE SUMMITVILLE MINE SUPERFUND SITE, COLORADO, USA

Campbell, A. (Colorado Dept. of Public Health and Environment, Denver, CO); M.J. Gobla (U.S. Bureau of Reclamation, Denver, CO)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1243-1250, ©2000

Numerous techniques for treating, controlling, and preventing acid rock drainage have been applied at the Summitville Mine Superfund Site. Challenging aspects of the remote mine site include the wide-spread occurrence of acid-generating soils and rocks, extensive surface and underground mine workings, and a cold and wet climate. Water treatment was an immediate necessity when the government took control of the abandoned site in December of 1992. Subsequent reclamation activities have emphasized prevention and control of ARD to minimize future water treatment requirements. A combination of conventional, innovative, and experimental methods are being applied to successfully mitigate ARD at Summitville.

INNOVATIVE IN SITU TREATMENT OF ACID MINE DRAINAGE USING SULFATE-REDUCING BACTERIA

Canty, M., MSE Technology Applications, Inc., Butte, MT

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1139-1148, ©2000

Results are presented that were gathered during field-scale testing of an innovative technology, sulfate-reducing bacteria (SRB), designed to treat and control acid mine drainage (AMD). The project was performed under the Mine Waste Technology Program (MWTP), which is funded by the U.S. EPA and jointly administered by the EPA and the U.S. DOE through an Interagency Agreement. The MWTP is implemented by MSE Technology Applications, Inc., located in Butte, MT. A field-scale test is described in which the subsurface workings of an abandoned mine were used as an in situ biological reactor.

AN INJECTION TECHNIQUE FOR IN-SITU REMEDIATION OF ABANDONED UNDERGROUND COAL MINES

Canty, G.A.; J.W. Everett
Univ. of Oklahoma, Dept. of Civil Eng. and Env. Science, Norman, OK

American Society for Surface Mining and Reclamation (ASSMR) Annual National Meeting: Proceedings of the 15th Annual National Meeting, 17-21 May 1998, St. Louis, MO
American Society for Surface Mining and Reclamation, Princeton, WV. p 690-697, 1998

Given the physical constraints associated with introducing amendments to a subterranean

environment, remediation of underground mines can prove to be a difficult task. An acid mine abatement project involving an in situ chemical treatment method was conducted by the University of Oklahoma. The treatment method called for the injection of an alkaline coal combustion by-product (CCB) slurry into a flooded mine void to create a buffered zone. Equipment developed by the petroleum industry for grouting recovery wells was used to inject the CCB slurry under significant pressure and at a high rate. With higher pressure and rates of injection, a large quantity of slurry could be introduced into the mine relatively quickly, and, theoretically, the method would improve dispersal of the slurry within the void. A total of 418 tons of CCB was introduced into the mine within 15 hours, and it is likely that a much larger mass could have been added. One injection well was drilled into a pillar of coal. Although this situation could pose a problem when introducing a slurry, the coal pillar was easily fractured during the injection process. Post-injection testing has shown the pH of the mine discharge is above 6.5.

AMBIENT TEMPERATURE FERRITE PROCESS FOR ACID ROCK DRAINAGE TREATMENT
Choung, J.W.; Z. Xu Univ. of Alberta, Edmonton, AB); J.A Finch (McGill Univ., Montreal, PQ)
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1101-1112, ©2000

Acid rock drainage (ARD) is a recognized environmental challenge facing mining industries. An ambient temperature ferrite (ATF) process has been investigated for treating ARD. Most nonferrous metal and calcium ions present in typical ARDs were found to be detrimental to the ATF process. Three approaches were examined, including CO2 aeration, addition of complex agents, and use of magnetic seeds. By introducing magnetic seeds in the ATF process, the interferences were minimized and all the precipitates formed with lime neutralization were magnetically recovered from a simulated ARD. The residual concentrations of major metal ions in the treated water were environmentally acceptable. The XRD pattern confirmed the spinel ferrite crystal structure of the products.

PROCESSES CONTRIBUTING TO THE REMOVAL OF MANGANESE FROM MINE DRAINAGE BY AN ALGAL MIXTURE
Clayton, L. D.; T. R. Wildeman
Proceedings of 15th Annual Meeting of American Society for Surface Mining and Reclamation, 17-22 May 1998, St. Louis, MO.
American Society for Surface Mining and Reclamation, Princeton, WV. p 192-201, 1998

BIOLOGICAL SULFATE REMOVAL AND METAL RECOVERY FROM MINE WATERS
De Vegt, A.L. (Paques Inc., Exton, PA); H.G. Bayer; C.J. Buisman
Mining Engineering, Vol 50 No 11, p 67-70, 1998

Paques, Inc. has been engaged since 1988 in the development and installation of bioremediation systems to remove sulfur compounds from water and gaseous streams. Metal and sulfate can be removed from mine waters in two biological steps. First, sulfate-reducing bacteria convert sulfate tohydrogen-sulfide, and the hydrogen sulfide reacts with dissolved metals to form insoluble metal sulfide precipitates. Then sulfide-oxidizing bacteria convert excess hydrogen sulfide to elemental sulfur. In the Netherlands in 1992, the Budelco Zinc Refinery installed and began to operate a ground-water treatment system to remove metals and sulfate using the biological steps described above. The system treats 180,000 cubic feet per day. In another application, a pilot plant began operation in November 1995 at Kennecott's

Bingham Canyon Utah copper mine to develop processes for metal and sulfate removal from ground water and for selective recovery of copper from leach water. This paper presents the principles of the biotechnological methods, the full-scale experience, and an overview of the test program at the mine.

FULL SCALE BIOLOGICAL TREATMENT OF HEAVY METAL CONTAMINATED GROUNDWATER

De Vegt, A.L. (Paques, Inc., Exton, PA); C.J.N. Buisman (Paques B.V., Balk (Netherlands)) Treatment and Minimization of Heavy Metal-Containing Wastes 1995: Annual Meeting and Exhibition of the Minerals, Metals and Materials Society (TMS), 12-16 February, Las Vegas, NV. p 69-79, 1995

Soil and groundwater beneath a zinc production plant in The Netherlands are contaminated with metals and sulfate. To avoid contamination of nearby drinking water aquifers, a hydro-geological containment system and a biological treatment plant for the extracted ground water have been installed. Currently about 5,000 M[sup 3]/day of groundwater is extracted from a combination of 12 shallow and deep wells. Heavy metals and sulfate have to be removed from the extracted water before it can be discharged into a river. Several water treatment methods have been studied and pilot tested at the site. The preferred and selected process is based on the activity of sulfate reducing bacteria (SRB) and combines sulfate removal and heavy metal removal in one single installation. Anaerobic bacteria reduce sulfate to sulfide resulting in the precipitation of metal sulfides. Excess sulfide is biologically converted to elemental sulfur. A full scale biological treatment system was started up in May 1992.

THE SELECTIVE OXIDE SYSTEM(TM): ACID DRAINAGE TREATMENT THAT AVOIDS THE FORMATION OF SLUDGE

Diz, Harry R.; Charles E. Via

Dept. Of Civil Engineering, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA

Mine Water and the Environment, Vol 17 No 1, p 1-6, Aug 1998

A new, relatively simple approach to treating acidic mine drainage has been developed. A bioreactor is used to oxidize ferrous iron, and a fluidized bed reactor causes the iron to precipitate onto the surfaces of seed particles. A trickling filter is used to oxidize and precipitate manganese at high (>9) pH. Copper, zinc and nickel are also removed, apparently by sorption onto oxide surfaces. The technology avoids the generation of iron sludge and the need for sedimentation basins.

FLUIDIZED BED FOR REMOVING IRON AND ACIDITY FROM ACID MINE DRAINAGE

Diz, H.R.; J.T. Novak

Dept. of Civ. Eng., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA

Journal of Environmental Engineering, Vol 124 No 8, p 701-708, Aug 1998

A fluidized bed reactor (FBR) for the removal of iron from acid mine drainage (AMD) was evaluated as part of a prototype multistage system, which included a bioreactor to oxidize ferrous iron, an FBR for the precipitation of ferric iron as a coating on media, and a carbonate bed (CB) for pH control. In the integrated system, a 99% iron removal efficiency was achieved, with effluent iron concentration remaining < 3 mg/L^{-1} and pH>6. The optimum pH for iron removal in the FBR was about pH 3.5. Above that pH, and above an iron loading of about 0.20 mg Fe/h^{-1}/m^{-2} reactor surface area, suspended iron particles developed in the reactor system. Particulates in the feed had an adverse impact on the removal performance of the system. Schwertmannite appeared to be the predominant mineral formed in the precipitation reactor. Coating growth on the sand media appeared to result from the attachment and

consolidation of small iron particles (<1.0\gmm) that formed in the bulk solution.

EXPERIMENTAL INJECTION OF ALKALINE LIME SLURRY FOR IN-SITU REMEDIATION OF AN ACIDIC SURFACE-MINE AQUIFER

Donovan, J.J.; J. Frazier; M. Daly; E. Werner; P.F. Ziemkiewicz; C. Black, West Virginia Univ., Morgantown, WV

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1001-1016, ©2000

Injection of alkaline waste-lime slurry was performed at a West Virginia surface coal mine site to attempt neutralization of acid springs by an alkaline recharge method. Deep trenching (>5 meters) using an excavator yielded the most effective injection into the aquifer. Water from two springs 90 meters from the deep trench showed 70-80% reduction in acidity in response to injection. Neutralization persisted more than 170 days after treatment, with pH ranging between 5.1-5.7 and metal acidity from 25-60 mg/L. A minor fraction of the introduced lime was consumed. The sustained neutralization is attributed to reaction of acid water with subsurface lime, entrained below the water table by macropore infiltration. Characteristics of ground-water transport are critical in determining recharge structure location.

CREATING WETLANDS ON ACID GENERATING TAILINGS: MAINTENANCE FREE RECLAMATION?

Eger, P.; G. Melcert; D. Antonson; J. Wagner; J. Folman
Minnesota Dept. of Natural Resources, St. Paul, MN

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1149-1158, ©2000

Current approaches to reclaiming acid generating tailings include permanent water cover or encapsulation with various synthetic liners and/or clay. Although these methods can be effective, some ongoing maintenance will be required in perpetuity to ensure that water levels are adequately maintained or that the integrity of any capping system is protected. The successful creation of wetlands in tailings basins offers the possibility of creating a stable environment for the tailings with minimal maintenance. Acid-generating tailings from a massive zinc sulfide deposit in Winston Lake, ON, were placed in small cylindrical tanks to examine the feasiblity and effectiveness of creating wetlands and mitigating acid and metal release. Two uncovered controls were established in addition to the five treatments, which were done in duplicate. The pH within the tailings in the treated tanks generally ranged between 6.0 and 6.5 and zinc concentration ranged from 0.02 to 0.1 mg/L. The drainage from the controls had an average pH of 3.3, and 7,700 mg/L of zinc.

TREATMENT OF ACID MINE DRAINAGE SLUDGE BY LEACHING AND METAL RECOVERY USING ACTIVATED SILICA

El-Ammouri, E.; P.A. Distin; S.R. Rao; J.A. Finch; K. Ngoviky, McGill Univ., Montreal, PQ

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1087-1094, ©2000

Sludges produced by lime treatment of acid mine drainage (AMD) can contain significant

quantities of base metals which represent both a potential hazard and a loss of values. A new technique for metal recovery from sludge is proposed by combining selective acid leaching and adsorption of metal ions by activated silica sol. The process is demonstrated on two AMD sludges, one containing primarily nickel and the second zinc. They were first treated with sulfuric acid (pH 3.5) to selectively leach the target metals and then activated silica sol was added to the leach solution to adsorb the nickel and zinc. Thickening and centrifuging gave about 90% rejection of the input volume to effluent. The adsorbed metals were redissolved by strong acid into a concentated solution relative to the feed and the silica sol was recycled.

CONCEPTS OF CHEMICAL AND BIOLOGICAL REMEDIATION OF ACIDIC, IRON-CONTAINING LAKES IN MINING AREAS
Fischer, R.; T. Guderitz
Wissenschaftliche Zeitschrift - Technischen Universitat Dresden, Vol 45 No 2, p 85-89, 1996

The extensive lowering of ground water, connected with intensive lignite mining in the areas concerned, brings about specific problems of water balance and especially of water quality as a result of pyrite and markasite materials weathering. For mining drainage water, the issue of remediation of mining lakes and prediction of the ground-water quality is of increasing importance. The extremely low pH-level and high percentage of iron considerably restricts the utilization of mining lakes as recreational and fishing waters as well as for the production of drinking water. Remediation concepts based on neutralization, hydrolysis, and precipitation are presented. The basis of the concepts are laboratory tests for the neutralization of strongly acidic mining lakes by means of soil drainage and percolation through buffering soil succession of shifts as well as the direct entry of neutralization material. As a result, the water quality should meet the demands of the EU guidelines for recreational and fishing waters.

BIOREMEDIATION OF URANIUM CONTAMINATED SOILS AND WASTES
Francis, A.J., Brookhaven National Lab., Dept. of Applied Science, Upton, NY
Proceedings of the 2nd Uranium Mining and Hydrogeology International Conference and Workshop, 15-17 Sep 1998, Freiberg in Sachsen, Germany
GeoCongress, Vol 5 Pt 1, p 340-346, 1998. Report No: BNL-65782. NTIS: DE99000606/XAB. 8 pp, Dec 1998

Microbes can biotransform uranium and toxic metals sufficiently to permit stabilization and removal of the contaminants. Stabilization exploits the unique metabolic capabilities of the anaerobic bacterium Clostridium sp. The bacteria solubilize the radionuclides and toxic metals either directly by enzymatic reductive dissolution or indirectly by the production of organic acid metabolites. The metals released into solution are immobilized by enzymatic reductive precipitation, biosorption, and redistribution with stable mineral phases in the waste. Removal can be accomplished by extracting the uranium and toxic metals from wastes or soils with the complexing agent citric acid. The citric-acid extract is subjected to biodegradation to recover the toxic metals and followed by photochemical degradation of the fraction of the uranium citrate complex that resists biodegradation. The toxic metals and uranium are recovered separately for recycling or disposal.

BIOTREATMENT OF METAL MINE WASTE WATERS: CASE HISTORIES
Fricke, J. (Advanced GeoServices Corporation, Sandy, UT); R. Blickwedel; P. Hagerty
Fourth International Symposium on Environmental Geochemistry, 5-10 Oct. 1997, Vail, CO
U.S. Geological Survey Open-File Report 97-0496, p 25, 1997

FIELD INVESTIGATION OF EVAPORATION FROM FRESHWATER TAILINGS
Fujiyasu, Y. (Kiso-Jiban Singapore Pte Ltd., Singapore); M. Fahey (Univ. of Western Australia, Nedlands); T. Newson (Univ. of Dundee, Dundee, UK)
Journal of Geotechnical and Geoenvironmental Engineering, Vol 126 No 6, p 556-567, Jun 2000

Safe and economical storage of tailings is now a major consideration in the operation of many mining operations. Tailings in slurried form, particularly if they have a significant clay content, can take a very long time to consolidate under the action of self-weight consolidation alone. However, if the operation is located in an area of high potential evaporation, this can be used to accelerate the rate of tailings densification. This paper presents a study of the evaporation behavior of a clayey tailings slurry deposited into an evaporation pond in the southwest of Western Australia. Over a six-month period, the rate of evaporation from the tailings surface was monitored using the Bowen Ratio method and the microlysimeter method. This was compared with the evaporation from a Class A pan located nearby. The tailings underwent very significant cracking as drying proceeded, and it was found that these cracks had a significant influence on the overall rate of evaporation once the top surface of the deposit started to desaturate. A large strain consolidation model was used to model the behavior, and the algorithm used in this model to include the effects of evaporation is shown to provide a reasonable prediction of the observed evaporation behavior.

MANAGING THE PH OF AN ACID LAKE BY ADDING PHOSPHATE FERTILISER
George, D.G.; W. Davison
Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation
Springer, New York. ISBN: 354063486X. p 365-384, c1998

IN SITU TREATMENT OF CYANIDE-CONTAMINATED GROUNDWATER BY IRON CYANIDE PRECIPITATION
Ghosh, Rajat S.; David A. Dzombak; Richard G. Luthy; John R. Smith
Water Environment Research, Vol 71 No 6, p 1217-1228, 1999

In cyanide-contaminated ground water, metal-cyanide complexes, especially iron-cyanide complexes, typically dominate aqueous speciation. Cyanide is relatively mobile in ground-water systems when metal-cyanide complexes behave typically as nonadsorbing solutes in sand-gravel aquifer systems in the neutral pH range. The researchers examined the feasibility of using in situ precipitation of iron cyanide in a reactive barrier to attenuate the movement of cyanide in ground water. Cyanide solutions were passed through mixtures of sand and elemental iron filings in laboratory column experiments, and the removal of dissolved cyanide was evaluated in a variety of cyanide-containing influents under various flow rates and sand-to-iron weight ratios. Maximum cyanide removal efficiency was achieved with approximately 10% by weight of iron in the sand-iron mixtures; higher iron contents did not increase removal efficiency significantly. The test results suggest that in situ precipitation is a promising passive treatment approach for cyanide in ground water.

BIOREMEDIATION IN SITU OF SOILS CONTAMINATED WITH RADIOACTIVE ELEMENTS
Groudev, S.N. (Univ of Mining and Geology, Sofia, Bulgaria); P.S. Georgiev; I.I. Spasova; K. Komnitsas
Bioremediation of Metals and Inorganic Compounds: Proceedings from the Fifth International In Situ and On-Site Bioremediation Symposium, 19-22 April 1999, San Diego, CA
Battelle Press, Columbus, OH. ISBN: 1-57477-077-2, p 103-108, 1999

In 1998, uranium, thorium, radium, copper, cadmium, and lead in an experimental plot were treated in situ by means of bioremediation based on indigenous soil microflora. The treatment was connected with the dissolution of the pollutants in the upper soil horizons and their transfer into more deeply located soil horizons, where they were immobilized as different insoluble compounds. The dissolution of the metals was connected with the activity of both heterotrophic and chemolithotrophic aerobic microorganisms, and the immobilization was due mainly to anaerobic sulfate-reducing bacteria. Biological activity was enhanced by adjustments to water, oxygen, and nutrient contents in the soil.

PASSIVE TREATMENT OF MINING EFFLUENTS IN LA LIBERTAD, PERU
Grubb, D.G.; G.W. Hudock; J. Pacora
Environmental Geotechnics, Vol 2
Balkema, Rotterdam. p 679-684, 1998

OPERATIONAL RESULTS OF A 1,200 GPM PASSIVE BIOREACTOR FOR METAL MINE DRAINAGE, WEST FORK, MISSOURI
Gusek, J. (Knight Piesold, LLC, Denver, CO); C. Mann; D. Murphy (Doe Run Co., Viburnum, MO); T. Wildeman (Knight Piesold, LLC, Denver, CO and Colorado School of Mines, Golden, CO)
Fifth International Conference on Acid Rock Drainage(ICARD), 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1133-1138, ©2000

An active underground lead mine produces water having a pH of 8.0 with 0.4 to 0.6 mg/L of Pb and 0.36 mg/L of Zn. This water is pumped at the rate of 1,200 gpm into a five-cell, bioreactor system covering about 5 acres. The gravity flow system is composed of a settling basin followed by two anaerobic bioreactors arranged in parallel which discharge into a rock filter polishing cell that is followed by a final aeration polishing pond. The primary lead removal mechanism is sulfate reduction/sulfide precipitation. The discharge has met stringent in-stream water quality requirements since its commissioning in 1996. However, there have been startup and operational difficulties. The system was designed to last about 12 years, but estimates suggest a much longer life based on anticipated carbon consumption in the anaerobic cells.

THE REMOVAL OF SULFATE AND METALS FROM MINE WATERS USING BACTERIAL SULFATE REDUCTION: PILOT PLANT RESULTS
Hammack, R.W. (U.S. DOE, Pittsburgh, PA); A.L. de Vegt (Paques, Inc., Exton, PA); A.L. Schoeneman (National Inst. for Occupational Safety and Health, Pittsburgh, PA)
Mine Water and the Environment, Vol 17 No 1, p 8-26, Aug 1998

A treatment process that bacterially converts sulfate into elemental sulfur via a hydrogen sulfide intermediate was demonstrated at pilot scale for the treatment of three mine waters that contained metals and sulfate. Ethanol served as the bacterial carbon and energy source. The mine waters were treated at

rates that ranged from 50-150 L day-1 . Contaminant concentrations up to 13 mg L-1 copper, 0.1 mg L-1 mercury, 0.04 mg L-1 cadmium, 3.5 mg L-1 zinc, 0.68 mg L-1 cobalt, 1.3 mg L -1 nickel, 49 mg L-1 iron, and 63 mg L-1 aluminum were removed to meet water quality effluent limits. Manganese removal was about 80% under normal operating conditions but increased to 96% when the process was optimized for manganese removal. The process was shown to be capable of decreasing sulfate concentrations from 1800 mg L-1 to less than 250 mg L-1, nitrate from 100 mg L-1 to less than 1 mg L-1, arsenic from 8 mg L-1 to less than 0.03 mg L-1, and calcium from 310 mg L-1 to less than 100 mg L-1. Acid mine waters were neutralized using bacterially-generated alkalinity; no external alkalinity source was needed.

ABATEMENT OF ACID MINE DRAINAGE BY CAPPING A RECLAIMED SURFACE MINE WITH FLUIDIZED BED COMBUSTION ASH

Hellier, William W., Pennsylvania Dept. of Environmental Protection, Hawk Run, PA

Mine Water and the Environment, Vol 17 No 1, p 28-40, Aug 1998

A watershed in north-central Pennsylvania was being polluted by acidic drainage from a surface coal mining operation. To abate the pollution, a thick cement mix based on fluidized bed combustion (FBC) ash was applied to the regraded surface, after which the site was covered with topsoil and revegetated. The FBC ash cement layer serves as an aquitard, preventing infiltrating rainfall from reaching acid-forming units in the backfilled mine. The horizontal components of ground water flow to the site are negligible. Consequently, acid formation was inhibited, and the concentrations of Fe, Mn, and Al were diminished substantially below levels present in the ground water and surface discharges before the application of the fly ash. Cr, Cu, Pb, Ni, and Zn are not present at detection limits in the receiving stream, while only a trace of Se is present . Benthic macroinvertebrate populations have improved markedly.

DRAFT GUIDING PRINCIPLES FOR CONSTRUCTED TREATMENT WETLANDS: PROVIDING WATER QUALITY AND HABITAT

Interagency Workgroup on Constructed Wetlands, 39 pp, 8 Jun 1999

This draft document includes guiding principles for siting, design, construction, operation, maintenance, and monitoring of constructed treatment wetlands; information on current Agency policies, permits, regulations, and resources; and answers to common questions. The Guiding Principles were developed by the Interagency Workgroup on Constructed Wetlands (U.S. Environmental Protection Agency, Army Corps of Engineers, Fish and Wildlife Service, Natural Resources Conservation Services, National Marine Fisheries Service, and Bureau of Reclamation). It is available at http://www.epa.gov/owow/wetlands/constructed/guide.html

CHEMICAL TREATMENT OF ACID MINE DRAINAGE FROM THE KING'S MINE AT ROEROS, NORWAY

Iversen, E.R.; R.T. Arnesen (Norwegian Inst. for Water Research, Oslo, Norway); C.H. Knudsen (Knudsen Prosjekt AS, Drammen, Norway)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1079-1086, ©2000

Recovery of iron and copper from acid mine drainage was studied in pilot scale at a continuous treatment plant at the mine site of the King's mine in Roeros, Norway. The average load on the plant was 1 m3/h. The process tested in this project is a three-step process consisting of 1) Fe(OH)3 precipitation at pH

3.5, dewatering of iron sludge and transport to ferric chloride plant; 2) precipitation after filtration of residual metals at pH 9, concentration of metal sludge by flotation; and 3) extraction of metals from the sludge with sulfuric acid followed by recovery of copper by electrolysis. The copper could be used for local production of different crafts, but this condition needs a further evaluation. The process economy at a full scale plant is evaluated.

NOVEL APPROACHES FOR BIOREMEDIATION OF ACIDIC, METAL-RICH EFFLUENTS USING INDIGENOUS BACTERIA
Johnson, B.; M. Dziurla; A. Kolmert, Univ. of Wales, Bangor, UK
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1209-1219, ©2000

Acidophilic bacteria are well known for their role in accelerating the oxidative dissolution of sulfide minerals, such as pyrite. Other acidophiles, however, are able to catalyze dissimilatory reductive reactions. Bacteria that reduce ferric iron to ferrous, and sulfate to sulfide, were isolated from ARD-impacted environments and immobilized onto porous beads made of recycled glass. Column bioreactors containing colonized beads were constructed and percolated with synthetic and actual ARD, and evaluated for their capacities to promote iron or sulfate reduction, and pH amelioration. Iron reduction did not require strictly anoxic conditions in bioreactors, and rates of up to 800 mg Fe^{3+} reduced/(1 day) were achieved, with a conversion efficiency of up to 98%. Using mixed populations of acidophilic fungi and iron-reducing bacteria, the bioreactors were capable of promoting iron reduction using paper pulp as sole carbon and energy source.

USING MAGNETITES TO REMEDIATE HEAVY METAL WASTEWATERS FROM ACID-MINE DRAINAGE
Johnson, M.D.; R. Wingo; M. Valdez
Natural Microporous Materials in Environmental Technology
Kluwer Academic Publishers, Boston. NATO science series. Series E, Applied sciences; Vol 362. ISBN: 0792358880. p 411-416, c1999

BIOLOGICAL POLISHING OF ZINC IN A MINE WASTE MANAGEMENT AREA
Kalin, M.
Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation
Springer, New York. ISBN: 354063486X. p 321-334, c1998

SULFUR ACIDIC MINING LAKES IN GERMANY: WAYS OF CONTROLLING GEOGENIC ACIDIFICATION
Klapper, H.; M. Schultze, UFZ GmbH Centre for Environmental Research Leipzig-Halle, Magdeburg (Germany). Section of Inland Water Research
Fourth International Conference on Acid Rock Drainage, 31 May-6 June 1997, Vancouver, Canada
CANMET, Natural Resources Canada, Ottawa, ON (Canada). Vol 4, p 1727-1744, 1997

The main cause of the sulphurous acidity found in about 100 mining lakes in eastern Germany is oxidation of pyrite from surface lignite mining. Methods for neutralization of these lakes into well

functioning ecosystems are described, in particular, water pollution abatement and the related problems of salinization, contamination, eutrophication, saprobization, and infection. The chemical characteristics and life conditions of the acidic environment and acidification control are discussed. Several ways to foster alkalinity production by microbial processes are outlined.

TREATMENT OF MINE DRAINAGE BY ANOXIC LIMESTONE DRAINS AND CONSTRUCTED WETLANDS
Kleinmann, R.L.P.; R.S. Hedin; R.W. Nairn
Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation
Springer, New York. ISBN: 354063486X. p 303-320, c1998

APPROACHES FOR THE RESTORATION OF STRONGLY ACIDIC MINING LAKES
Kleinmann, R.L.P.
Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation
Springer, New York. ISBN: 354063486X. p 427-435, c1998

REHABILITATION OF HEAVY METAL-CONTAMINATED LAND BY STABILISATION METHODS
Kontopoulos, A.; P. Theodoratos
National Technical Univ. of Athens, Athens, Greece. Dept. of Mining and Metallurgical Eng.
Environment and Innovation in Mining and Mineral Technology: Proceedings of the 4th International Conference on Clean Technologies for the Mining Industry, 13-15 May 1998, Santiago (Chile)
Report No: CONF-9805163. ISBN: 956-227-159-5. Vol 2, p 939-951, 1998

This paper addresses the remediation of contaminated land at an abandoned lead-silver mine via stabilization techniques, aiming at converting the contaminants to forms that are less soluble, mobile, and bioavailable. The soil was mixed with inorganic and organic wastes: phosphate rock, fly ash, and biological sludge. The effectiveness of stabilization was evaluated by applying standard chemical extraction tests and by monitoring plant growth. The toxicity of soil was reduced below the TCLP regulatory limit with additions of phosphates, fly ash, and biological sludge. The bioavailable fraction of heavy metals was also reduced in most cases. The immobilization mechanism responsible for stabilization with phosphates was the formation of highly insoluble phosphate compounds. Fly ash
caused the precipitation of metal hydroxides because of the pH increase. The biological sludge brought about the complexation of the metal ions on the free radicals of the organic matter. Plant growth was affected positively with biological sludge additions and negatively with phosphates and fly ash.

BUMINES UNLEASHES CYANIDE-EATING BACTERIA
Lien, Richard
American Metal Market, Vol 103 No 112, p 11A(1), 12 Jun 1995

Tests results of a bioremediation research undertaken by the Bureau of Mines to remove selenium and cyanide from tailings pond water at a California wildlife refuge have been very successful. The research used both biological and chemical techniques that utilized a cyanide-oxidizing bacterial strain known as Pseudomonas. The new cyanide bio-oxidation technology is expected to
be of immense help to the gold-heap leaching industry.

REMEDIATION OF ACID MINE DRAINAGE (AMD) IN FLOW-THROUGH CONSTRUCTED WETLANDS: EFFECTS OF INFLUENT PH AND IRON CONCENTRATION
Magness, Mark C., Master's thesis, Dept. of Agronomy, Univ. of Maryland at College Park, 306 pp, 1996

REMEDIATION OF ACID ROCK DRAINAGE BY INDUCING BIOLOGICAL IRON REDUCTION
Marchand, E.A.; J. Silverstein, Univ. of Colorado, Boulder, CO
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1201-1208, ©2000

Competition between Thiobacillus ferrooxidans and non-iron-oxidizing heterotrophic bacteria was induced by the addition of glucose to a co-culture of T. ferrooxidans and A. acidophilum in an oxygen-limited environment. Iron oxidation was inhibited as dissolved oxygen was used preferentially for glucose metabolism. Furthermore, as the water became anoxic, glucose was consumed along with the oxidized iron species (Fe3+) during iron respiration resulting in a pH increase from 2.0 to 4.0. Results suggest that biologically mediated acidification of drainage water can be reversed by dispersion of an easy to degrade, soluble, and inexpensive carbon source such as glucose.

THE USE OF AN IN-SITU POROUS REACTIVE WALL TO REMEDIATE A HEAVY METAL PLUME
McGregorR.; M. Choi (Water Technology International, Burlington, ON); D. Blowes (Univ. of Waterloo, Waterloo, ON); R. Ludwig (U.S. EPA, Ada, OK)
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1227-1233, ©2000

The oxidation of sulfide minerals at an ore transfer location in Western Canada has resulted in widespread contamination of underlying soil and groundwater. The oxidation of sulfide minerals has released sulfate and heavy metals including cadmium, copper, nickel, lead, and zinc into the groundwater. A compost-based sulfate-reducing reactive wall was installed in the path of the plume in an attempt to reduce the potential impact of the heavy metals on a down-gradient marine inlet. Monitoring of the reactive wall over a 21-month period has shown that Cu concentrations decrease from over 4000 µg/L to less than 5 µg/L. Cd, Ni, Pb, and Zn concentrations also show similar decreases with treated concentrations generally being observed near or below detection limits.

DEMONSTRATION OF AN INNOVATIVE HEAVY METALS REMOVAL PROCESS
McLaughlin, Richard E., McLaughlin Water Engineers, Denver, CO
Tailings and Mine Waste '96, 16-19 January, Fort Collins, CO
A.A. Balkema, Rotterdam; Brookfield, VT. p 443-450, 1996

The issues considered during the development of a new Heavy Metals Removal Process (HMRP) for the treatment of acid mine drainage are analyzed. The proposed HMRP has been used successfully at a Superfund sitefor almost five years. This system has been able to handle flow rates as high as 400 gpm. This new HMRP was created as a replacement system for a conventional process used at the Eagle Mine Superfund site. The previous system was unable to treat the required volume of water on a consistentbasis.

The new system has lower capital costs than alternative treatment methods. In addition, operating costs and sludge volume are kept to aminimum. The HMRP remains viable even for cases involving high sulfate concentrations.

REVEGETATION OF A MINE TAILINGS IMPOUNDMENT USING MUNICIPAL BIOSOLIDS IN A SEMI-ARID ENVIRONMENT
McNearny, R.L., Dept. of Mining Eng., Univ. of Utah, Salt Lake City
Bridging Gaps in Technology and Culture: Proceedings of the 1998 Conference on Hazardous Waste Research, 18-21 May, Snowbird, UT
Kansas State Univ., Manhattan, KS. p 87-100, 1998

In 1994, five separate test sites were established on a tailings impoundment belonging to the Kennecott Utah Copper Corporation near Magna, Utah, to evaluate the use of municipal sewage sludge (biosolids) as a soil amendment and conditioner. Each site was divided into 16 test plots to evaluate four replications of the four rates of biosolids incorporated into the tailings. The sites were monitored for potential leaching of total heavy metals, total metals, extractable metals, plant tissue analysis for heavy metals, biomass production, agronomic properties, and plant species diversity. This paper presents the results through the second year of the project and notes changes in the properties of soils and vegetation after two growing seasons. The agronomic properties of the tailings showed continued improvement following the initial biosolids addition. Significant improvements were seen when comparing the control plots to all treated plots. A statistically significant continued improvement in biomass production and percent cover by plant species occurred for all biosolids application rates when compared to the control plots. For additional information:
http://www.engg.ksu.edu/HSRC/98Proceed/index.html

REVIEW OF PASSIVE SYSTEMS FOR TREATMENT OF ACID MINE DRAINAGE
MEND Secretariat CANMET, Ottawa, Ontario. MEND Report 3.14.1, May 1996 (Revised 1999)

Passive treatment systems utilize the chemical, biological and physical removal processes that often occur naturally in the environment to modify the influent characteristics. Passive treatment systems were initially considered attractive to treat acid mine drainage due to their lower costs of construction, operation and maintenance, and their ability to operate at remote locations with limited operational requirements. The objective of this project was to review passive treatment systems, and make recommendations on their applicability to treat acid mine drainage in Canada. In this review, four major types of passive technologies for the treatment of acid mine drainage have been examined: anoxic limestone drains; constructed wetlands; microbial reactor systems; and biosorption systems. This document offers summaries of known passive treatment technologies, maintenance and monitoring requirements, life expectancy and long term implications, implications of treatment product disposal, estimates of costs for the technologies described based on generic cases, ability to meet Canadian Metal Mining Liquid Effluent Regulations and control toxicity, descriptions of case studies, and general assessments of the applicability of current passive treatment systems to Canadian mine sites.

TREATMENT OF ACID ROCK DRAINAGE: FIELD DEMONSTRATION OF SILICA MICRO ENCAPSULATION TECHNOLOGY AND COMPARISON WITH AN EXISTING CAUSTIC SODA-BASED SYSTEM

Mitchell, P.; C. Potter (KEECO Ltd., Penryn, Cornwall, UK); M. Watkins (Univ. of Bath, Bath, UK)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1035-1044, ©2000

Meldon Quarry is a seemingly rare occurrence of acid rock drainage (ARD) in a quarrying operation. With surface waters discharging to a tributary of a salmon-bearing river, it is subject to stringent discharge conditions. The quarry predates effective environmental management, and preventative, control, and treatment measures were not implemented until relatively recently. Retrospectively implementing standard preventative approaches at the site is costly, technically difficult, and of uncertain benefit. This paper overviews the site history and introduces data from a demonstration by KEECO (UK) Ltd. of its Silica Micro Encapsulation water treatment technology.

RELOCATION AND SUBMERGENCE OF NET-ACID-GENERATING WASTE ROCK FOR CONTROL OF ACIDIC DRAINAGE: A CASE STUDY

Morin, K.A.; N.M. Hutt

Fifth International Conference on Acid Rock Drainage(ICARD), 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 819-825, ©2000

One technique for controlling ongoing acidic drainage is to relocate and submerge net-acid-generating waste rock in a lake or water-retaining impoundment. This can lead to the overall improvement of water quality and the reduction in short-term environmental liabilities. A case study of this technique is the Eskay Creek mine in northern British Columbia. Some findings of the study are: 1) the addition of lime to each truckload of rock, based on its rinse pH, neutralized the accumulated acidity and suppressed the accumulated-metal release, 2) only 10-20% of the dump's neutralization potential had been consumed when acidic drainage appeared, 3) water chemistry in the watershed recovered roughly three years after relocation, and 4) environmental liability was reduced due to the cessation of on-land acidic drainage with no degradation of lake chemistry.

HEAVY METAL REMOVAL USING PEAT/WETLAND TREATMENT

Murawski, Suzanne

Critical Issues in Water and Wastewater Treatment: Proceedings of the 1994 National Conference on Environmental Engineering, 11-13 July 1994, Boulder, Colorado

New York: ASCE. ISBN: 0-7844-0031-8, p 408-414, 1994

FIELD DEMONSTRATION OF PERMEABLE REACTIVE BARRIERS TO CONTROL RADIONUCLIDE AND TRACE-ELEMENT CONTAMINATION IN GROUND WATER FROM ABANDONED MINE LANDS

Naftz, D.L. (U.S. Geological Survey, Salt Lake City, UT); et al.

Proceedings of the 7th National Toxic Substances Hydrology Program Meeting, Charleston, SC, March 8-12, 1999. Volume 1: Contamination from Hardrock Mining
U.S. Geological Survey Water-Resources Investigations 99-4018. Vol 1, p 281-288, 1999

A demonstration project to evaluate the removal of uranium from ground water by means of six different permeable reactive barriers (PRBs) is underway in 1999 at an abandoned uranium upgrader operation site in Fry Canyon in southeastern Utah. Two methods of PRB deployment, the funnel-and-gate design and non-pumping well design, were installed to passively treat uranium-contaminated ground water. The six different PRBs have removed uranium from the ground water with varying levels of efficiency. With respect to the PRBs installed using a funnel and gate, the barrier containing zero-valent iron has consistently removed more than 99.9 % of the input uranium concentration during the first year of operation. The percentage of uranium removed in the bone char phosphate and amorphous ferric oxyhydroxide PRBs was slightly less, averaging 94.0 and 88.1%, respectively. The three barrier deployment tubes in the non-pumping wells containing mixtures of bone-char phosphate and iron-oxide pellets removed less uranium than the PRBs deployed using the funnel-and-gate design. Numerous geochemical and hydrological factors that affect uranium removal efficiencies and processes in each of the PRBs will be evaluated.

MICROBIOLOGICAL TREATMENT OF CYANIDE, METALS, AND NITRATES IN MINING BYPRODUCTS

Nordwick, S.; M. Canty; R. Hiebert (MSE Technology Applications,.Inc., Butte, MT); L. Thompson (Pintail Systems, Inc., Aurora, CO)

Bioremediation of Metals and Organic Compounds: Fifth International In Situ and On-Site Bioremediation Symposium, 19-22 April 1999, San Diego, CA
Battelle Press, Columbus, OH. ISBN: 1-57477-077-2. p 31-36, 1999

Contaminants typical in mine process waters include cyanide, metals, and nitrates. This paper describes the successful application of a biological treatment system designed to detoxify contaminants from mining cyanide leach operations. Liquid from the McCoy/Cove Mine was used in a pilot-plant demonstration during which several metals were immobilized, cyanide was detoxified, nitrates were removed, and pH was neutralized. The demonstration was sponsored by the Mine Waste Technology Program, which is funded by EPA and jointly administered by DOE and EPA's SITE program.

TREATMENT OF MINE DRAINAGE WATER USING A COMBINED PASSIVE SYSTEM

Ordonez, A.; J. Loredo; F. Pendas, Univ. of Oviedo, Oviedo, Spain

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1121-1132, ©2000

Water derived from mine tailings typically contains high concentrations of H+, SO4, Fe, and other metals, and it frequently suffers a decline in pH and the development of acidic mine drainage (AMD). This paper describes the results of a series of laboratory experiments with real AMD and a subsequent field trial with an in situ pilot system to assess a potential method for remediating tailings-derived water. After testing different organic substrates, residence times, and flow conditions over the course of two years to determine

the most appropriate treatment for a polluted Spanish AMD, a pilot-scale system combining SAPS, ALD, oxidation/sedimentation ponds, and an anaerobic wetland was designed. Preliminary analyses of effluent samples indicate acidity and metal removal is occurring within the system, although sulfate removal is not complete. The results of this small field trial suggest a potential cheap, long-term alternative for remediation of acid mine drainage.

IN-LAKE NEUTRALIZATION OF ACID MINE LAKES
Peine, A.; S. Peiffer
Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation
Springer, New York. ISBN: 354063486X. p 47-64, c1998

BIOREMEDIATION OF METALS IN ACID TAILINGS BY MIXED MICROBIAL MATS
Phillips, P.; J. Bender
Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation
Springer, New York. ISBN: 354063486X. p 347-364, c1998

PILOT-SCALE PASSIVE TREATMENT TEST OF CONTAMINATED WATERS AT THE HISTORIC FERRIS-HAGGARTY MINE, WYOMING
Reisingev, R.W.; J.J. Gusek (Knight Piesold and Co., Denver, CO); T.C. Richmond, Wyoming Dept. of Environmental Quality, Cheyenne, WY)
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1071-1078, ©2000

A high-altitude (9,500 ft) historic underground copper mine in Wyoming is discharging copper-laden water with a neutral pH into an otherwise pristine creek. The Wyoming Abandoned Mine Land program is reclaiming the site under a CERCLA deferral agreement. The cleanup goal is to reduce copper in the mine discharge so that the creek can eventually support a trout fishery. A pilot-scale passive treatment test utilizing sulfate-reducing bacteria has been in progress at the site since the summer of 1997. Test results show significant reduction in copper concentrations in near-freezing mine water at flow rates up to 19 liters per minute (5 gpm).

EXPERIENCE: ACID TRIP
Robertson, Alan, Pacrim Environmental Pty Ltd. (pacrim@hunterlink.net.au)
Groundwork, No 1 Vol 2, Sep 1998 (Available online at http://www.ameef.com.au/groundwk.htm)

The author, a Senior Environmental Scientist with Pacrim Environmental Pty. Ltd., received the 1997 Australian Minerals & Energy Environment Foundation's Travelling Scholarship to investigate overseas practices in the management of acid drainage. From May to July 1998, he visited over sixteen mine sites and six centers of research excellence in New Zealand, the U.S., Canada and The Netherlands. The U.S. tour included visits to two active mine sites—Greens Creek Silver/Zinc Mine, Juneau, Alaska, and Bingham Canyon Copper Mine—currently managing sulphidic mine wastes, and two historical mine sites—Leadville, Colorado, and the Berkeley Pit in Butte, Montana—with a legacy of ongoing environmental degradation due to inappropriate past management. At each of these sites, the author was able to examine, in detail, the management practices being used to deal with the acid drainage problem.

EVALUATION OF PASSIVE SYSTEMS FOR THE TREATMENT OF MINE DRAINAGE
Roscoe, Heath C., Master's thesis, Pennsylvania State Univ., University Park
NTIS: ADA362851. 234 pp, May 1999

Acid Mine Drainage (AMD) is a serious environmental problem and the focus of a great deal of research. Passive treatment systems associated with wetlands and Anoxic Limestone Drains (ALDs) provide a low-cost, low-maintenance treatment in contrast to continuous chemical metering. The ALD adds alkalinity to the water allowing for a more rapid formation of iron precipitates. The abiotic oxidation ponds associated with these systems are expected to precipitate about 10-20 g/sq m-day of iron. The focus of this research is to evaluate two different ALD passive treatment systems in order to find ways to improve the efficiency of the abiotic oxidation of ferrous, thereby reducing the amount of land area required to treat the discharge. The two systems evaluated differed in that one system is a channel system, while the other is a series of ponds. The channel system has a large excess of alkalinity while the pond system has net mineral acidity. The study of the systems was conducted over a one-year period starting in January 1998 and ended in January 1999. The evaluation of each system included monitoring the chemistry and using MINTEQA2, a chemical equilibrium computer program to assist in the analysis. Of all the major cations in solution, ferrous is the only one that is removed in the system. The full text of the thesis is available through the DTIC search engine at http://www.dtic.mil/stinet/str/tr_fields.html.

WETLANDS TREAT MINE RUNOFF
Sanders, F. (McCulley, Frick & Gilman, Inc., Boulder, CO), J. Rahe; D. Pastor; R. Anderson (Hydrometrics, Inc., Helena, MT)
Civil Engineering—ASCE, Vol 69 No 1, p 52-55, Jan 1999

Engineers were asked to design a treatment system for the severely acidic drainage from the Mike Horse and Anaconda metals mines in Montana. Challenges included the mountainous terrain, brutally cold temperatures, large snowfalls, and a lack of on-site electricity, as well as the composition of the drainage, which had a moderately acidic pH, moderate zinc concentrations and moderate iron concentrations. The solution is an integrated treatment system made up of flow-through plugs at the mines; in-line oxidation system (ILS) for passive oxidation of ferrous iron; a pretreatment basin for iron hydroxide settling and coprecipitation of zinc; sand filtration for iron; and polishing of residual metals in constructed wetland cells. Monitoring data from October 1998 show that the treatment system is meeting all discharge restrictions for iron, lead, copper and cadmium, and the wetland cells are still developing their capacity to retain zinc.

BIOREMEDIATION ENGINEERING OF MINING & MINERAL PROCESSING WASTES
Sengupta, Mritunjoy
Northwest Academic Pub. ISBN: 0965302504, 1997

REMOVAL OF DISSOLVED HEAVY METALS FROM ACID ROCK DRAINAGE USING IRON METAL
Shokes, Tamara E.; Gregory Moller
Environmental Science & Technology, Vol 33 No 2, p 282-287, 15 Jan 1999

Iron metal addition to acid rock drainage increases system pH, removes dissolved heavy metals, and enhances sulfate reducing bacteria populations. The chemical and microbial activity of corroding iron

metal is examined in the acid rock drainage (ARD) resulting from pyrite oxidation to determine the effectiveness in neutralizing the ARD and reducing the load of dissolved heavy metals. ARD from Berkeley Pit, MT, is treated with iron in batch reactors and columns containing iron granules. Iron, in acidic solution, hydrolyzes water producing hydride and hydroxide ion resulting in a concomitant increase in pH and decrease in redox potential. The dissolved metals in ARD are removed by several mechanisms. Copper and cadmium cement onto the surface of the iron as zerovalent metals. Hydroxide forming metals such as aluminum, zinc, and nickel form complexes with iron and other metals precipitating from solution as the pH rises. Metalloids such as arsenic and antimony coprecipitate with iron. As metals precipitate from solution, various other mechanisms including coprecipitation, sorption, and ion exchange also enhance removal of metals from solution. Corroding iron also creates a reducing environment supportive for sulfate reducing bacteria (SRB) growth. Increases in SRB populations of 5,000-fold are observed in iron metal treated ARD solutions. Although the biological process is slow, sulfidogenesis is an additional pathway to further stabilize heavy metal precipitates.

ARD REMEDIATION WITH LIMESTONE IN THE CO2 PRESSURIZED REACTOR

Sibrell, P.L.; B.J. Watten (U.S. Geological Survey, Kearneysville, WV); A.E. Friedrich (PA Dept. of Environmental Protection, Harrisburg); B.J. Vinci (The Conservation Fund Freshwater Institute, Shepherdstown, WV)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1017-1026, ©2000

The authors evaluated a new process for remediation of acid rock drainage (ARD) that treats ARD with intermittently fluidized beds of granular limestone maintained within a continuous flow reactor pressurized with CO2. Tests were performed over a 30-day period at the Toby Creek mine drainage treatment plant, Elk County, Pennsylvania, in cooperation with the Pennsylvania Dept. of Environmental Protection. Iron, aluminum, and manganese removal efficiencies of 96%, 99%, and 5%, respectively, were achieved with filtration following treatment. No indications of metal hydroxide precipitation or armoring of the limestone were observed. The surplus alkalinity established at 82 kPa was successful in treating an equivalent of 1136 L/min (five-fold dilution) of the combined three ARD streams entering the Toby Creek Plant. This side-stream capability offers savings in treatment unit scale as well as flexibility in treatment effect.

THE CAPACITY OF NATURAL WETLANDS TO AMELIORATE WATER QUALITY: A REVIEW OF CASE STUDIES

Sobolewski, A., Microbial Technologies, Vancouver, BC

Fourth International Conference on Acid Rock Drainage, 31 May-6 June 1997, Vancouver, Canada
CANMET, Natural Resources Canada, Ottawa, ON (Canada). Vol 4, p 1549-1563, 1997

Case studies of natural wetlands for treating mine drainage are described. Most of the sites are in northern Canada. The natural wetlands examined suggest that constructed wetlands are a viable option for the passive treatment of mine drainage. Natural wetlands retain many metals, and many species of plants are represented in them. Processes for metal removal include sorption onto organic matter, hydrolysis, and reduction. The results show that wetlands need not be based on cattails to be effective, and that passive mine drainage treatment is feasible in northern regions. Few examples are available of constructed wetlands for treating metal mine drainage. It is concluded that the limitations of constructed wetlands are found not in the wetlands, but in information about them.

REMEDIATION OF HISTORICAL MINE SITES: TECHNICAL SUMMARIES AND BIBLIOGRAPHY
Society for Mining, Metallurgy, and Exploration (SME) with American Geological Institute (AGI)
Society for Mining, Metallurgy, and Exploration, Littleton, CO. 118 pp, c1998

This publication identifies existing or developing environmental remediation methods that may have current or future application to historical hard-rock mining sites. It is intended as an introduction to the currently known range of methods that may represent alternatives to expensive removal or pump-and-treat technologies.

TREATMENT OF COAL MINE DRAINAGE WITH A COMPOST-LIMESTONE REACTOR
Tarutis, W.J., Jr.; T.M. Walski; K.M. Klemow
Innovative Technologies for Site Remediation and Hazardous Waste Management: Proceedings of the National Conference, 23-26 July 1995, Pittsburgh, Pennsylvania
New York: ASCE. ISBN: 0-7844-0095-4, p 141-148, 1995

A QUANTITATIVE APPROACH TO OPTIMIZE CHEMICAL TREATMENT OF ACID DRAINAGE USING GEOCHEMICAL REACTION PATH MODELING METHODS: CLIMAX MINE, COLORADO
Tempel; R.N.; M.F. Lengke (Univ. of Nevada, Reno NV); R.C. Ford (Cyprus Climax Metals Co., Tempe, AZ); T.E. Eastep; B.R. Romig; G. Clothier (Climax Molybdenum Co., Climax, CO)
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1053-1058, ©2000

The Climax mine, near Leadville, CO, treats acid drainage in a lime neutralization chemical treatment system. Chemical treatment has been successful in reducing the concentration of metals to below surface water discharge effluent limits, but lime usage has not been optimized. A geochemical modeling approach has been developed to increase the efficiency of lime neutralization. The modeling approach incorporates two steps: calibration and calculation of amount of lime needed to increase pH and remove metals. Results of the work quantify the lime treatment process and improve the ability to predict overall water quality.

FIELD RESULTS FROM AN ANAEROBIC CONSTRUCTED-WETLAND SYSTEM USED TO DEMONSTRATE REMEDIATION OF ARD FROM A COAL STORAGE FACILITY
Thomas, R.C.; C.S. Romanek (Univ. of Georgia, Aiken, SC and Athens, GA); D.P. Coughlin (Univ. of Georgia, Aiken, SC); K.W. Paul (Montana State Univ., Bozeman, MT)
Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1177-1184, ©2000

Two separate constructed treatment wetland (CTW) systems receiving the same metal-contaminated, acid sulfate water over different lengths of time and at different rates were evaluated for metal attenuation. Both wetlands are the alkalinity generator portion of a successive alkalinity producing system (SAPS). Sequential extractions are employed to determine phases of metal removal. Results indicate that Fe, Al, Zn, Ni, and Cu accumulate in the organic substrate over time. Manganese accumulates

initially, but is not retained in the system over time.

APPLICATIONS OF PERMEABLE BARRIER TECHNOLOGY TO GROUND WATER CONTAMINATION AT THE SHIPROCK, NM, UMTRA SITE
Thomson, B.M.; E.J. Henry; M.S. Thombre
Univ. of New Mexico, Albuquerque, NM. Dept. of Civil Engineering
Proceedings of the 1996 Hazardous Substance Research Center/Waste-Management Education and Research Consortium Joint Conference on the Environment, 21-23 May 1996, Albuquerque, NM
Kansas State Univ. Manhattan, KS, p 89-102, 1996

The Shiprock uranium mill tailings pile in far northwestern New Mexico consists of approximately 1.5 million tons of uranium mill tailings from an acid leach mill which operated from 1954 to 1968. Located on land owned by the Navajo Nation, it was one of the first tailings piles stabilized under the Uranium Mill Tailings Remedial Action (UMTRA) project. Stabilization activities were completed in 1986 and consisted principally of consolidating the tailings, contouring the pile to achieve good drainage, and covering the pile with a multi-layer cap to control infiltration of water, radon emanation, and surface erosion. No ground water protection or remediation measures were
implemented other than limiting infiltration of water through the pile, although a significant ground water contamination plume exists in the flood plain adjacent to the San Juan River. The major contaminants at the Shiprock site include high concentrations of sulfate, nitrate, arsenic, and uranium.
One alternative for remediation may be the use of a permeable barrier in the flood plain aquifer. As proposed for the Shiprock site, the permeable barrier would be a trench constructed in the flood plain that would be backfilled with a media that is permeable to ground water, but would intercept or degrade the pollutants. Work to date has focused on use of a mixed microbial population of sulfate and nitrate reducing organisms. These organisms would produce strongly reducing conditions which would result in precipitation of the metal contaminants (i.e., Se(IV) and U(IV)) in the barrier. One of the first considerations in designing a permeable barrier is developing an understanding of ground water flow at the site. Accordingly, a steady state numerical model of the ground water flow at the site was developed using the MODFLOW code. The paper is available on the KSU Web site at
http://www.engg.ksu.edu/HSRC/96Proceed

REMEDIATION PROCESSES FOR HEAVY METALS CONTAMINATED SOILS
Torma, G.A.; A.E. Torma (AMROT International, Rio Rancho, NM); Pei-Cheng Hsu (Mining and Waste Management, Arvado, CO)
Second International Symposium on Extraction and Processing for the Treatment and Minimization of Wastes, 27-30 Oct 1996, Scottsdale, AZ
Minerals, Metals, Materials Society, Warrendale, PA. p 289-304, 1996

This paper provides information on selected technologies available for remediation of metal contaminated soils and industrial effluent solutions. Because some of the industrial sites are contaminated with organics (solvents, gasolines and oils), an effort has been made to introduce the most frequently used cost-effective cleanup methods, such as bioventing and composting. The microorganisms involved in these processes are capable of degrading organic soil contaminants to environmentally harmless compounds: water and carbon dioxide. Heavy metals and radionuclides contaminated mining and industrial sites can be remediated by using adapted heap and dump leaching technologies, which can be chemical in nature or bio-assisted. The importance of volume reduction by physical separation is discussed. A special attention is devoted to the remediation of soils by leaching

(soil washing) to remove heavy metal contaminants, such as chromium, lead, nickel and cadmium. Furthermore, the applicability of biosorption technology in the remediation of heavy metals and radionuclides contaminated industrial waste waters and acidic mining effluent solutions was indicated.

TECHNICAL CONSIDERATIONS FOR THE IMPLEMENTATION OF SUBSURFACE MICROBIAL BARRIERS FOR RESTORATION OF GROUNDWATER AT UMTRA SITES
Tucker, M.D., Sandia National Labs., Albuquerque, NM
Report No: SAND-96-1459. NTIS: DE96012418. 47 pp, Jan 1996

The Uranium Mill Tailings Remediation Action (UMTRA) Program is responsible for the assessment and remedial action at the 24 former uranium mill tailings sites located in the United States. The surface remediation phase, which has primarily focused on containment and stabilization of the abandoned uranium mill tailings piles, is nearing completion. Attention has now turned to the groundwater restoration phase. One alternative under consideration for groundwater restoration at UMTRA sites is the use of in-situ permeable reactive subsurface barriers. In this type of a system, contaminated groundwater will be allowed to flow naturally through a barrier filled with material that will remove hazardous constituents from the water by physical, chemical or microbial processes while allowing passage of the pore water. The subject of this report is a reactive barrier that would remove uranium and other contaminants of concern from groundwater by microbial action (i.e., a microbial barrier). The purpose of this report is to assess the current state of this technology and to determine issues that must be addressed in order to use this technology at UMTRA sites. The report focuses on six contaminants of concern at UMTRA sites including uranium, arsenic, selenium, molybdenum, cadmium and chromium. In the first section of this report, the fundamental chemical and biological processes that must occur in a microbial barrier to control the migration of contaminants are described. The second section contains a literature review of research that has been conducted on the use of microorganisms to immobilize heavy metals. The third section addresses areas that need further development before a microbial barrier can be implemented at an UMTRA site.

SELECTION OF REACTIVE MIXTURES FOR USE IN PERMEABLE REACTIVE WALLS FOR TREATMENT OF MINE DRAINAGE
Waybrant, K.R.; D. W. Blowes; C. J. Ptacek
Golder Associates Ltd, Burnaby, BC, Canada
Environmental Science and Technology , Vol 32 No 13, p 1972-1979, 1 Jul 1998

Geochemically reactive walls offer a promising passive treatment alternative for remediating metal-contaminated ground water derived from oxidized mine wastes when they are installed in the path of migrating ground water. Contaminants are removed from the ground water as a result of bacterial sulfate reduction and the subsequent precipitation of sparingly soluble sulfide solids. Eight organic-carbon reactive mixtures were assessed for permeability and reactivity. Mixtures containing several organic sources were most reactive. Results from these studies suggest that levels of reactivity and permeability suitable for remediating tailings-contaminated ground water can be attained by porous, permeable, geochemically reactive walls.

PHYSIOLOGICAL RESPONSES OF SWITCHGRASS (PANICUM VIRGATUM L.) TO ORGANIC AND INORGANIC AMENDED HEAVY-METAL CONTAMINATED CHAT TAILINGS

Youngman, A.L., Wichita State Univ., KS. Dept. of Biological Sciences

The 12th Annual Conference On Hazardous Waste Research: Building Partnerships For Innovative Technologies; 20-22 May 1997, Kansas City, MO
Kansas State Univ., Manhattan, KS. Report No: CONF-9705104. p 556-563, 1997

Study plots established at the Galena sub-site of the Cherokee County Superfund Site in Southeastern Kansas by the US Bureau of Mines in 1990 were examined during the summer of 1996 to determine whether physiological criteria could be used to determine suitability of switchgrass for remediation of heavy-metal contaminated substrates. Treatment plots included a treatment control, an organic residue treatment of 89.6 Mg Ha-1 composted cattle manure, and two inorganic fertilizer treatments recommended for either native grass or grass/legume mixtures. Plant response variables were photosynthetic rate, leaf conductance to water vapor, internal concentration of carbon dioxide in leaves, foliar transpiration rate, leaf water-use-efficiency, predawn leaf xylem water potential, and midday leaf xylem water potential. Predawn and midday xylem water potentials were higher for grass/legume inorganic treatment than for the other inorganic treatments. Leaf conductances were lower for organically treated plots than those plots not organically amended and both photosynthesis and transpiration were lower for organically treated plots. Leaf conductances and transpiration were higher for grass/legume treated plots than for plots lacking inorganic treatment. Water-use-efficiency was higher for native grass inorganically treated plots than for other inorganic treatments.

PERFORMANCE OF FIELD-BIOREACTORS WITH SULFATE-REDUCING BACTERIA TO CONTROL ACID MINE DRAINAGE

Zaluski, M.; J. Trudnowski; M. Canty; M.A.H. Baker
MSE Technology Applications, Inc., Butte, MT

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1169-1176, ©2000

Three sulfate-reducing bacteria (SRB) passive field bioreactors were constructed at an abandoned mine site near Butte, MT, to mitigate AMD emanating from a waste rock pile. Each SRB field bioreactor contains chambers of an organic source, limestone, and cobbles. The bioreactors are configured differently to test the effect of different environmental conditions on the SRB. Preliminary observations indicate that, during start up and the first eight months of operation, the quantity of organic carbon supply significantly impacts the SRB activity. To date, the dissolved metals have been reduced significantly and the pH has increased.

AN ASSESSMENT OF HDS-TYPE LIME TREATMENT PROCESSES — EFFICIENCY AND ENVIRONMENTAL IMPACT

Zinck, J.M.; W.F. Griffith, CANMET, Ottawa, ON

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO
Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1027-1034, ©2000

Four different high density sludge-type processes, Cominco HDS, Geco HDS, Tetra HDS Process, and the Staged-neutralization process were studied for their effectiveness in treating a low strength Zn-Fe rich acidic drainage solution. Each process was run continuously for at least two weeks after obtaining

steady state conditions. The final effluent quality, lime consumption, sludge density, settleability, filterability, viscosity, neutralization potential, metal leachability, operating and capital costs were measured and evaluated for each process.