Tuesday 8:45 - Robert Kleinmann

Keynote Address

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Biography

Dr. Robert Kleinmann currently directs the Geosciences Division of the U. S. Dept. of Energy, National Energy Technology Laboratory in Bruceton, PA. Bob holds a Ph.D. in Geology from Princeton University.

His interest in environmental geology started as an undergraduate at Penn State, and continued as a grad student where he liked the idea that researching acid mine water drainage required interdisciplinary skills rather than the highly specialized skill that most graduate work entails. That thesis research resulted in a patent whose basis is that Fe oxidizing bacteria are responsible for pyrite oxidation and resultant AMD. He developed a technique to inhibit these bacteria that is still in use today. Bob was hired in 1979 by the old Bureau of Mines to start an acid mine water research group. In 1980, Bob was involved in one of the first passive treatment attempts using sphagnum moss to treat small seeps in Ohio. This approach was a precursor to the development of constructed wetlands that encourages bacteria to flourish and metabolize metals.

Dr. Kleinmann is active in the American Society of Mining and Reclamation and serves as Vice-president of the International Mine Water Association. He is also editor-in-chief of the quarterly journal Mine Water and the Environment and has published over 100 technical articles on the subject of AMD.

Tuesday 9:15 - Brent Means

Overview of Passive Treatment in Pennsylvania

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Abstract
During the past decade, Pennsylvania has experienced a strong growth in the formation of watershed groups that use public money to build treatment systems on abandoned mine discharges. The Office of Surface Mining, Harrisburg Field Office, recently completed a database that records spatial, financial, and project information for these treatment projects. The database shows over $60 million dollars of public money have been spent on treating mine drainage since 1995. The State of Pennsylvania's Growing Greener initiative has contributed to the most projects followed by the EPA 319 program, OSM Watershed Cooperative Agreement program, OSM Clean Stream program, USDA PL566, OSM 10% set aside program, EPA Watershed Assistance program, and the USCOE. Querying the database shows that Schuylkill County contains the most projects, but Elk County received the most funding. Over 74% of the treatment projects are constructed on deep mine discharges while 21% have been built on surface mine discharges and the remaining on refuse discharges.

Biography
Mr. Means holds a MS degree in Hydrogeology from Wright State University. He previously worked for USGS and was in coal consulting before joining OSM 6 years ago in the Harrisburg Field Office. Brent has made mine water treatment his passion; acting as a leader within the agency for the development of new and improved treatment technologies; Brent is the technical lead in development of AMDTreat, software developed to cost out treatment options and determine financial forecasting of future expenditures. Also Brent has been a lead developer and instructor of the OSM Passive Treatment Course and has been instrumental in developing the technical program for the Mine Water Treatment Conference.

Tuesday 9:30 - James J. Gusek

Case Studies of Bioreactors

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Abstract
There are basically two kinds of biological passive treatment cells for treating mine drainage. Aerobic Cells containing cattails and other plants are typically applicable to coal mine drainage where iron and manganese and mild acidity are problematic. Sulfate Reducing Bioreactors (SRBRs) are typically applicable to metal or coal mine drainage with high acidity and/or a wide range of metals. Most passive treatment systems employ one or both of these cell types. The track record of aerobic systems in treating coal mine drainage is impressive, especially in the eastern coalfields. SRBR's have tremendous potential at metal mines and especially acidic coal mines but have not seen as wide an application.

This paper presents the rudiments of SRBR design and operation in treating mine drainage, including the ability to work in cold, high altitude environments; handle high flow rates of mildly affected ARD in moderate acreage footprints; treat low pH/acid drainage with a wide range of metals and anions including uranium, selenium, and sulfate; accept acid drainage containing dissolved aluminum without clogging with hydroxide sludge.

SRBRs might not be applicable in every abandoned mine situation. A phased design program of laboratory, bench, and pilot scale testing has been shown to increase the likelihood of a successful design.

Biography

Mr. James J. Gusek is a Senior Project Manager with Golder Associates, Inc. based in Lakewood, Colorado and a registered professional engineer. He specializes in mine closure, mine land reclamation and design of passive treatment systems for mine influenced water. Since 1987, his work with acid rock drainage prevention and passive water treatment systems has included over three dozen projects throughout the U.S. and in England, Zambia, Malaysia, Fiji, Slovakia, Peru, Brazil, and Chile. He has published dozens of papers about passive treatment of mine influenced water, in particular acid rock drainage, and is a co-chair of the Metal Mining Sector of the Acid Drainage Technology Initiative. He graduated from the Colorado School of Mines in 1973 with a B.S. in Mining Engineering.

Tuesday 10:00 - Glenn C. Miller

Ethanol Fed, Semi-Passive Bioreactors at the Leviathan Mine

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Abstract

The use of sulfate-reducing bioreactors to treat acid mine drainage has advantages over current active treatment technologies due to the passive to semi-passive nature of the treatment as well as the lower volumes of sludge produced, which both contribute to lower operational costs. In 2002, a semi-passive bioreactor was constructed at the Leviathan Mine, Alpine County California. This remote site is located at approximately 7000 ft elevation on the eastern slope of the Sierra Nevada Mountains. Alcohols are utilized by sulfate-reducing bacteria to reduce sulfate to sulfide and precipitate metals as metal-sulfides. Because alcohols do not freeze under normal site conditions, this carbon and energy source can be gravity fed to supply the bacteria with specific concentrations of reducing equivalents throughout the year. A rock matrix with large pore spaces is utilized in conjunction with a flushing mechanism to reduce the chance of plugging and short circuiting within the bioreactor. In addition, the majority of the metals are removed outside of the bioreactor. Treated water, laden with sulfide is mixed with untreated water in a settling pond where the metals are removed. Water, essentially free of metals, is then passed through the bioreactor where sulfate-reduction and sulfide generation occurs. This system is less active than conventional lime treatment and can operate for longer periods of time without replacement of the matrix when compared to traditional passive bioreactors.

Biography

Glenn C. Miller is a Professor of Natural Resources and Environmental Science at the University of Nevada, Reno. He is also the Director of the Graduate Program in Environmental Sciences and Health at UNR. He has a B.S. in Chemistry from the University of California, Santa Barbara and a Ph.D. in Agricultural and Environmental Chemistry (1977) from the University of California at Davis. Following graduate studies, he spent a year of postdoctoral study at the EPA's Environmental Research Laboratory in Athens, Georgia and has been at UNR since 1978. Current areas of research include acid mine remediation using anaerobic sulfate reducing systems, closure of precious metals heaps, and precious metals pit water quality. In the recent past he has examined emissions from marine engines into Lake Tahoe and the associated risks with those emissions. He teaches courses in Environmental Toxicology, Risk Assessment and Environmental Chemistry. He is a member of the American Chemical Society, SETAC, AAAS and Sigma Xi.

Tuesday 10:30 - Linda Ann Figueroa

Microbial Ecology of Anaerobic Biosystems Treating Mining Influenced Waters

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Abstract

Anaerobic passive biosystems (e.g., wetlands and sulfate reducing bioreactors) rely on sulfate-reducing bacteria (SRB) for remediation of mining influenced waters. The SRB reduce the sulfate ion to sulfide, which leads to an increase in pH and precipitates the dissolved metals as insoluble sulfide metals. Anaerobic biosystems however are comprised of a complex microbial consortium, the SRB being only one of many different genera of bacteria present in a sulfate reducing biozone. The survival of SRB is closely related to the health of the microbial community in which they live. Because SRB are unable to breakdown cellulose (the major organic component in wetlands and compost bioreactors) directly for their energy needs they must rely on cellulolytic - fermenting bacteria to provide the necessary substrates, such as lactate and b utyrate. Thus, it is important to understand the environmental constraints necessary to maintain a healthy community of cellulolytic - fermenting bacteria, who are responsible for the hydrolysis of cellulose into cellobiose and glucose, and subsequent fermentation to lactate and butyrate. This presentation is an overview of the current understanding of the microbial ecology of anaerobic biosystems and the implications in terms of operation and design.

Biography

Dr. Linda A. Figueroa is an Associate Professor of Environmental Science and Engineering at the Colorado School of Mines. She is a registered professional engineer and has more than 20 years of experience in research and design of treatment processes. Prior to joining the Colorado School of Mines she held engineering positions at environmental engineering consulting companies. She has more than 30 technical papers and journal articles in the area of treatment.

Since 1992 Dr. Figueroa has been involved in the remediation and treatment of metals and radionuclides primarily with bioprocesses. Dr. Figueroa is active in the Acid Drainage Technology Initiative-Metal Mining Sector where she is involved in the review and development of resources on available technology options for mine sites. Dr. Figueroa is the technology focus area leader of the Rocky Mountain Regional Hazardous Substance Research Center for Mine Waste Remediation. Her teaching experience has included courses on microbiology, treatment and waste management.

Tuesday 12:40 - Art Rose

Long-Term Performance of Vertical Flow Ponds

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Abstract
Increasingly, it is recognized that many vertical flow ponds (SAPS) are not performing up to expectations over the long term. This paper extends the data on performance and problems previously presented, with the addition of new sites and updated information.

Of 39 sites, about half are performing satisfactorily. Four sites have essentially ceased to treat. Most of the remainder are treating at a moderate level, but not up to original expectations. Problems are overflow because of plugging by Fe precipitate on top of compost or by Al precipitate in limestone, leakage, decreased treatment because of short circuiting or Al coating, or inadequate size for the acidity loading. Several systems have been rebuilt at low cost and are performing satisfactorily. Areal loading of Fe and Al is an additional design parameter that should be considered.

Biography
Arthur W. Rose is Professor Emeritus of Geochemistry at Penn State University. He holds a PhD in Geology and Geochemistry from California Institute of Technology. After jobs for Kennecott Copper Co and the State of Alaska, he taught economic geology and applied Geochemistry at Penn State for 29 years. Starting in 1990, he supervised a number of theses and research projects on acid mine drainage prevention and passive treatment. In recent years he has presented numerous papers on passive treatment methods, and continues research in this area. He is active as Technical Chair with the Clearfield Creek Watershed Association, and is currently supervising construction of two vertical flow systems.

Tuesday 1:10 - Charles A. Cravotta III

Laboratory and field evaluation of limestone dissolution in passive systems for neutralization of acidic mine drainage

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Abstract
This presentation describes the use of short-term closed-container (cubitainer) tests to indicate limestone dissolution rates and the corresponding alkalinity of effluent as a function of detention time in a limestone bed for passive neutralization of acidic mine drainage (AMD). Various test configurations can simulate conditions closed to the atmosphere (underground system) or open to the atmosphere (above-ground system) and the effects of limestone purity, secondary coatings, and particle size on dissolution rate. Coupled with data on the average flow rate and acidity concentration of the tested AMD, the cubitainer rate data can be used to estimate the long-term performance and minimum effective size of a limestone bed in an anoxic limestone drain (ALD) or comparable system.

Construction characteristics and data on influent and effluent composition were collected for 5 to 11 years at five limestone drains in Pennsylvania. Influent at the Morrison and Howe Bridge discharges in the Bituminous Coalfield had average pH of 5.3 and 5.8 and net acidity (= computed acidity – alkalinity) of 434 and 495 mg/L as $CaCO_3$, respectively. Influents at the Orchard, Buck Mtn., and Hegins discharges in the Southern Anthracite Coalfield were characterized by lower pH and acidity, with average pH of 3.5, 4.6, and 3.5 and net acidity of 30, 28, and 47 mg/L as $CaCO_3$, respectively. Effluent from each drain had higher pH, alkalinity, and Ca, and lower acidity, Fe, and Al concentrations than the influent. Although estimated detention time averaged 56 hours at Morrison, 22 hours at Howe Bridge, and less than 5 hours at the Orchard, Buck Mtn., and Hegins ALDs, net-alkaline effluent was produced from only the Orchard and Buck Mtn. ALDs. The long-term average flow multiplied by the difference between average concentrations of Ca for influent and effluent indicated average annual limestone dissolution rates of 1.0, 9.0, 1.5, 22.9, and 5.0 tonne/yr at the Morrison, Howe Bridge, Orchard, Buck Mtn., and Hegins drains, respectively. These annual dissolution rates have progressively declined with age of the systems as the limestone has been consumed.

For the five limestone drains in Pennsylvania, cubitainer tests with AMD influent from each of the sites indicated limestone dissolution rates were larger for high-purity limestone than for dolomite and for conditions closed to the atmosphere than open conditions, but the rates for fresh, uncoated versus environmentally exposed, metal-hydroxide-coated limestone were comparable for a given condition. The dissolution rates as measured by cubitainer tests, after corrections for surface area and fluid volume, were in agreement with field data for alkalinity and dissolved Ca production rate. Models developed on the basis of the cubitainer tests accurately revealed decadal-scale declines in limestone mass and corresponding alkalinity concentrations with increased age of a limestone treatment bed. Thus, cubitainer tests can be a useful tool for designing ALDs or similar systems and predicting their performance. Because a limestone bed could become plugged long before the limestone substrate has been consumed, engineering designs that are larger than the minimum size indicated by cubitainer tests and/or that incorporate provisions for flushing or replacement of the limestone bed could be warranted.

Biography
Dr. "Chuck" Cravotta is a research hydrologist at the U.S. Geological Survey Pennsylvania Water Sciences Center and adjunct Assistant Professor of Environmental Engineering at Penn State Harrisburg. He received his B.A. in Environmental Sciences from the University of Virginia and his M.S. and Ph.D. in Geochemistry and Mineralogy from the Pennsylvania State University. His research emphasizes field and laboratory applications of geochemical and hydrological methods for the characterization and treatment of drainage from coal mines.

Tuesday 1:40 - Danielle M C Huminicki

The Effect of Gypsum Coatings on Dissolution Rate of Calcite in AMD solutions

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Abstract
A common passive treatment for acid mine drainage (AMD) is to react it with limestone to neutralize its acidity and increase its net alkalinity. During treatment, secondary mineral coatings form on the limestone (armoring), which decreases its dissolution rate and reduces the effectiveness of this treatment. This research shows that gypsum can form epitaxially on calcite dissolving in sulfuric acid solutions by the coupled reaction

$$CaCO_3\ (cal) + H_2SO_4\ (aq) + 2H_2O = CaSO_4\bullet 2H_2O\ (gyp) + H_2CO_3\ (aq)$$

An array of batch reactor experiments measured the dissolution rates of Iceland spar calcite (Asp = 0.015m^2/g, 40-60 mesh fraction) at room temperature in 0, 0.1, 0.3, or 1.0 M solutions of sodium sulfate with pH values of 1.5, 2.0, 2.5, 3.0 or 3.5. Scanning electron microscopy (SEM) showed that gypsum coatings formed on calcite at low pH where sulfate concentrations were high. Rates of dissolution are reported in terms of moles of H^+ consumed. The apparent rate, r', was calculated by numerical differentiation and the rate, r = r'/A (mol/m^2sec). The general rate law selected as the best fit to the rate data was $r = kt^{-0.5}$. Calcite dissolution rates decline with time as the growing gypsum layer greatly reduces the rate of H^+ transport to the calcite surface. This physical behavior can be derived from Fick's first law of diffusion such that

$$k = 1/2[DCA/f(gyp)porosityV]^{0.5}$$

for the rate law stated above.

Biography
Danielle M. C. Huminicki completed a B. Sc. (Hons.) degree in geology at the University of Manitoba in 2000 under the supervision of Dr. Frank Hawthorne on the crystal chemistry of beryllium minerals. Part of this work was published in a chapter in the Reviews in mineralogy and geochemistry series. Following her B.Sc., she continued to work on the crystal chemistry of phosphate minerals, which is also published in a review in mineralogy and geochemistry chapter. After receiving her M. Sc. degree in 2002 she began her Ph. D. at Virginia Tech with Dr. J. D. Rimstidt as her advisor. She is working on iron and sulfur mineralogy and geochemistry and the important kinetic processes associated with the treatment and prevention of acid mine drainage
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Tuesday 2:50 - Bernard Aube

High Density Sludge Production when Treating Mine Waters

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Abstract
For many closed or operating mine sites, active lime treatment is the best alternative to treating acid mine drainage (AMD) resulting from the oxidation of sulphides. This is a relatively inexpensive and very effective means of meeting discharge requirements and has the advantage of being able to treat high acidity and high flow rates. Unfortunately, many types of treatment processes produce a voluminous sludge containing only 1 to 3 % solids, the remainder of the mass being tightly bound water. This presentation describes the factors that influence the production of a high-density sludge (HDS), a product that allows operators to save considerably on sludge disposal costs by reducing the volume of waste. These factors include the raw water chemistry, the process design, the reagents used, the process operating parameters, and equipment used. When the right combination is put together, sludges of more than 25% solids can be formed.

Biography
Mr. Aubé completed a Bachelor in Applied Sciences, Chemical Engineering, from University of Waterloo in 1992. He then worked on various aspects of mine environment at Noranda Technology Center for 10 years. During this time, he specialized in treatment of acid mine drainage and smelter effluents. Bernie obtained a Master's degree in Environmental Engineering from École Polytechnique (University of Montreal engineering School). His Master's thesis was on the comparison of the Geco and Conventional High-Density Sludge processes in a pilot scale. Bernie started his own consulting company in 2001, EnvirAubé, specializing in the design and optimization of treatment plants and sludge disposal. He is currently working on a project to treat zinc in a large pit lake in Northern Québec and consulting on a molybdenum treatment plant to be built in Chile.

Tuesday 3:20 - Timothy K. Tsukamoto

The use of an Innovative Rotating Cylinder Treatment System (RCTS) for Efficient Oxidation and Treatment of Acid Mine Drainage

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Abstract
Impacted acid mine drainage typically contains elevated concentrations of dissolved ferrous iron. The oxidation of ferrous iron to ferric iron is a common component to most lime treatment systems because ferric iron is precipitated from solution at a lower pH than ferrous iron. This oxidation is typically accomplished by pumping air with compressors and mixing the air, lime and water with agitation mixers in large tanks. Although this method of treatment is effective, it requires significant power and a large amount of space to house the reaction tanks. The Rotating Cylinder Treatment System (RCTS) "patent pending" utilizes shallow trough like cells (that contain the water being treated) and rotating cylinders to transfer oxygen and agitate the water. This system has been tested on multiple sites in Nevada and California. When compared with conventional systems it requires less power, and less space and is more efficient at mixing lime.

Key words: oxidation, aeration, lime treatment systems, acid mine drainage, acid rock drainage, water treatment, mining remediation, and passive treatment systems

Biography
Tim Tsukamoto is currently working as a Research Assistant Professor at the University of Nevada, Reno. He is the Principal of TKT Consulting, LLC, and is a Director for Ionic Water Technologies. He has worked in various aspects of the mining industry for the past 18 years and has developed acid mine drainage treatment and prevention technologies at sites throughout North America, including sites in Nevada, Montana, British Columbia and several sites in California. He has participated in the Leviathan Mine, the Colorado Hill, the Rio Tinto Mine, the Ely Mine and the Elizabeth Mine Technical Advisory Committees. Dr. Tsukamoto has a B.S. in Biology and a Ph.D. in Environmental Chemistry from the University of Nevada, Reno.

Tuesday 3:50 - Bradley R. Shultz

Acid Rock Drainage Sludge Management Issues at the I-99 Construction Site in State College, Pa

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Abstract
Over 900,000 cubic yards of pyritic material was unearthed during excavation work for constructing Interstate 99 near State College, Pennsylvania. The pyritic material was placed in fill disposal areas on-site, some layered with lime material. Upon determination of acidic discharges from the oxidation of pyritic material in the fill disposal areas, active treatment was employed using a caustic soda product to neutralize the acidic discharges. The existing settling basins originally designed for erosion and sediment control were used to provide detention of the chemically treated acidic discharges and settle out the precipitated metals. To prevent discharge of the solid materials and maximize retention time, periodic sludge removal from the basins is necessary. Geotextile tubes, pumps, polymer, a 2,500-gallon vacuum truck, and hard working individuals were used for handling and processing the sludge material from several of the basins in 2004. Estimates indicate over 2,000 cubic yards of sludge are produced monthly in the settling basins on the site. Processing of the sludge and allowing the material to dewater within the geotextile tube, yields a high solids cake-like material suitable for hauling and disposal. This methodology for processing sludge created during the treatment of acidic discharges, either rock or mine sources, has proven effective for handling high volumes of sludge material in preparation for hauling and disposal. With a year of working experience, this same method of sludge handling has been employed again at the I-99 project site in 2005.

Biography
Bradley R. Shultz is a Water Quality Scientist for Skelly and Loy, Inc. located in Harrisburg, Pennsylvania. He earned his Bachelor of Science degree from Millersville University in Marine/Aquatic Biology and his Masters Degree from Penn State University in Environmental Pollution Control. At Skelly and Loy Mr. Shultz has performed numerous tasks related to both acid rock and acid mine drainage issues throughout the state. In addition to passive and active treatment system design, Mr. Shultz has performed numerous field investigations to evaluate treatment system effectiveness and problem shooting through water chemistry investigations. Currently, Mr. Shultz is helping to oversee and perform the sludge handling and processing operations at the I-99 Construction Site immediately west of State College, PA, where iron and aluminum sludge is generated from the active treatment of acid rock drainage on the site.

Tuesday 4:20 - Kimberly R. Weaver

Engineering Self-flushing Systems for Mine Drainage Treatment: Theory and Practice

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Abstract
A common goal of passive mine drainage treatment is the removal metals such as iron and aluminum from contaminated water. However, these metals form solid particles that can clog pipes and limestone aggregate, increasing operational costs and decreasing treatment system longevity. To combat this problem, a wide variety of flushing systems have been installed in passive treatment systems. Flushing systems usually consist of a network of perforated pipes buried in limestone, which drain via valved header pipes. Periodically, the valves are opened to allow large amounts of water to flush through the system and, ideally, remove accumulated solids. In recent years, self-flushing systems have been used to treat mine drainage. Flushing, either via valves or with self-flushing siphons, theoretically extends the useful life of passive systems by restoring porosity. Unfortunately, flushing system design is poorly understood and most systems are not designed using scientific or engineering principles. Additionally, few systems are subjected to rigorous monitoring after they are constructed. The purpose of this paper is to provide a survey of flushing technologies currently being used, detail one method of using engineering principles to design flushing networks, and discuss the implications of this analysis on future flushing technologies.

Biography
Kim Weaver, P.E., is a project manager at Hedin Environmental, a small Pittsburgh PA consulting firm specializing in mine drainage assessment and treatment. As an undergraduate civil engineering student at Bucknell University, she assisted Dr. Carl Kirby with mine drainage research. She obtained a master's degree in Environmental Engineering from Princeton University. Ms. Weaver has worked at Hedin Environmental since 1999.

Wednesday 8:00 - Linda Ann Figueroa

Microbiology of Manganese Oxidation

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Abstract

The phenomenon of microbial manganese oxidation is well established. However, the design of microbial manganese oxidation systems is hampered by the lack of understanding about the specific conditions required to sustain microbial manganese oxidation. Recent studies suggest that the ability of microorganism to oxidize manganese is ubiquitous and specialized bacteria are not required. In addition, carbon stress and metal toxicity have been identified as factors that stimulate microbial manganese oxidation. This presentation will synthesize the current understanding of the microbiology and suggest strategies to improve the design and operation of microbial manganese oxidizing systems.

Biography

Dr. Linda A. Figueroa is an Associate Professor of Environmental Science and Engineering at the Colorado School of Mines. She is a registered professional engineer and has more than 20 years of experience in research and design of treatment processes. Prior to joining the Colorado School of Mines she held engineering positions at environmental engineering consulting companies. She has more than 30 technical papers and journal articles in the area of treatment.

Since 1992 Dr. Figueroa has been involved in the remediation and treatment of metals and radionuclides primarily with bioprocesses. Dr. Figueroa is active in the Acid Drainage Technology Initiative-Metal Mining Sector where she is involved in the review and development of resources on available technology options for mine sites. Dr. Figueroa is the technology focus area leader of the Rocky Mountain Regional Hazardous Substance Research Center for Mine Waste Remediation. Her teaching experience has included courses on microbiology, treatment and waste management.

Wednesday 8:30 - John Senko

Geomicrobiological characterization of Fe(II)- and Mn(II)-oxidizing activity at two mine drainage treatment sites

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William Burgos and Ashley Davidson, Penn State University

Abstract
We characterized geomicrobiological activities in two acid mine drainage treatment sites. A mine water discharge stream near Altoona, PA contains low pH (3.5) water with abundant soluble Fe(II) (2 mM), which remains at a high concentration over the course of the 29 m stream. Abundant Fe(III) crusts are evident in the stream, and oxygen concentration increases from approx. 5 µM to approx. 135 µM from the point of water emergence to the end of the stream. Fe(III) solids become less crystalline and less dense in regions as oxygen levels increase in the stream. Akaganeite and schwertmanninte predominate in the high-oxygen regions of the stream, while goethite is evident in the low-oxygen regions. Numbers of acidophilic, aerobic Fe(II)-oxidizing bacteria remain constant throughout the stream (approximately 6 x 10^4), suggesting that oxygen levels do not control numbers of Fe(II)-oxidizing bacteria, but may control the Fe(III) products formed by these organisms. Mn(II)-oxidizing activity was characterized in a limestone-based Mn removal bed located in Elk County, PA. Water (pH 5.2) emerges from an anoxic limestone drain and flows through a limestone bed where water pH increases to 6.5 at the end of the bed, with a corresponding decrease in soluble Mn(II) from 1.6 mM to less than 0.05 mM. Mn(II)-oxidizing bacteria comprise 20-44% of the total heterotrophic bacteria in the region of the bed where Mn(II) removal is occurring, suggesting that the prerequisite microorganisms for Mn(II) oxidation are present, and abundant in the Mn removal bed. Our results suggest that Fe(II)- or Mn(II)-oxidizing bacteria are present at acid mine drainage treatment sites whose activity may be exploited and stimulated for efficient removal of these metal contaminants.

Biography
John Senko received a B.S. in Biology from St. Vincent College in Latrobe, PA, an M.S. in Biology from Duquesne University, Pittsburgh, PA studying the enzymology of nitrate reduction in the iron-reducing bacterium Geobacter metallireducens, and his Ph.D. from the University of Oklahoma, Norman, OK studying anaerobic uranium reduction and oxidation with Lee Krumholz and Joe Suflita. Currently, he's a post-doc with the Center for Environmental Chemistry and Geochemistry at Penn State, working with Bill Burgos.

Wednesday 9:00 - Song Jin, Ph.D.

Biological Source Treatment of Acid Mine Drainage

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Abstract
Chemical neutralization, wetlands and other passive methods are widely used in treating acid mine drainage (AMD); however, none of these methods addresses the source of AMD, which continuously generates acid effluent and loads the treatment system with unlimited amount of acid water. Certain species of sulfate-reducing bacteria (SRB) can survive in acidic environments. The sulfate reducing metabolism consumes protons, resulting in the rise of pH and precipitation of metal sulfides. In this study, SRB consortium and substrates were amended to AMD to achieve a barrier of biofilm that coats the surface of metal sulfides, shielding oxidants from oxidizing AMD source compounds. Different sources of SRB and substrates were identified and evaluated. Microcosms containing AMD water were studied before the field applications. In the laboratory study, SRB activities were aggressive in AMD water with pH as low as 3.0. pH was raised to neutral range and stabilized for over a year upon the initial amendments of SRB and substrates. No sulfate reduction occurred in microcosms in which pH was below 3.0. By manipulating the dosage of SRB-substrate injection, biofilm formation and the metal-sulfides from the SRB metabolism can effectively consume the oxygen and mask the AMD source from being oxidized. The results from this study may offer a long-term and economical method of controlling AMD at its source. Field applications are currently undergoing at a coal mine in eastern Tennessee.

Biography
Dr. Song Jin is a Lead Scientist with the Western Research Institute in Laramie, Wyoming. He has a Ph.D. in Environmental Microbiology and an M.S. in Molecular Biology from the University of Wyoming. Dr. Jin's research includes aerobic and anaerobic biodegradation of various contaminants in soils and groundwater. He is also directing studies in biological control of Acid Mine Drainage and enhancement of biogenic methane production from coal and oil shale.

Wednesday 10:10 - Jonathan M. Dietz

Activated Iron Solids (AIS) Treatment: A Low Cost Long Term Active Treatment Alternative for High Iron AMD

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Abstract
Widespread deep coal mining has created numerous large underground reservoirs of ferrous iron-laden acidic mine drainage (AMD). These contaminated deep mine reservoirs typically discharge at high volumes (1 to 50 million gallons per day) and at single or multi-point locations. Treatment of these high flow AMD discharges has been accomplished using conventional lime-based treatment, but the high annual chemical, manpower and energy costs, as well as the disposal costs of the low-density (1-4% solids) and impure sludge has limited treatment to regulated discharges and long term treatment of these discharges is a significant liability. Passive treatment is typically not an option due to large land area requirements (20 to 200 acres), uncertain performance, and costly sludge removal. An innovative active treatment known as Activated Iron Solids (AIS) treatment of AMD (patent pending) has been developed to provide a low-cost active treatment alternative. The AIS process involves a self-perpetuating and catalytic surface chemistry oxidation process that occurs at slightly acidic pH to accomplish ferrous oxidation; the required step in the removal of iron from AMD. Also, the AIS process does not require the use of chemicals (e.g., lime) for net alkaline AMD and can use inexpensive powdered limestone for net acidic AMD. AIS Treatment forms a high-density (20 to 30% solids), high iron oxide purity (exceeding 95%) solid that are easily recovered. The AIS Treatment chemistry, experiences in AIS Treatment testing, various system designs will be discussed. Comparisons of AIS Treatment costs to current treatment conventions costs will be provided.

Biography

EDUCATION:
B.S., Biology and Earth Science, Clarion University, 1983
M.S., Environmental Pollution Control, Penn State University, 1989
Ph.D. Environmental Engineering, Penn State, University, 2003

Jon Dietz has spent more than 15 years in the consulting industry conducting NEPA studies, water quality and aquatic ecology assessments, R&D of innovative technologies, and designing mine drainage treatment systems. Jon returned to Penn State University from the consulting industry in 2000 to continue his education and study environmental chemistry & engineering and has recently graduated with his Doctorate in Environmental Engineering. During his doctorate Jon developed "new" heterogeneous (surface chemistry) ferrous iron sorption & oxidation kinetic models, which he has used to develop the next generation of AMD treatment systems, known as AIS/SBR treatment of mine drainage. Jon also conducted research into abiotic manganese oxidation kinetics and alkalinity generation from limestone, based on kinetics and solubility reactions, which he has used to develop new passive treatment approaches. During his professional career Jon has conducted numerous AMD abatement projects including watershed assessments, watershed restoration plans, and prepared final and conceptual designs for over 30 discharges in the eastern U.S. coal region. He also has provided technical expertise on water resource studies including a variety of Environmental Assessments (EA), Environmental Impact Statements (EIS), 319 thermal discharge studies, National Pollution Discharge Elimination System (NPDES) studies, and surface water quality standards for ammonia (that have been promulgated for New Jersey waters). Jon has authored and/or co-authored over 50 technical reports, journal articles, proceedings and presentations during his professional career.

Wednesday 10:40 - Daryle H. Fish

Activated Iron Sludge Treatment Using a Sequencing Batch Reactor: Performance evaluation with both acidic and alkaline mine drainage

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Abstract

An innovative new treatment system has been designed and constructed for the lower discharge of Saxman Run. The treatment system uses the activated iron sludge (AIS) process in a sequencing batch reactor (SBR). In this process the iron oxide sludge produced during remediation is used as catalyst the oxidation of Fe^{+2}. The treatment system has been in operation for about two years, and is capable of remediation about 40 GPM of flow in a 10,000-gallon reactor. We will discuss the performance of the reactor, and its ability to treat acidic waters using alkaline additions directly into the treatment reactor. Economics of direct addition of alkalinity versus installation of an ALD will be compared.

Biography

Daryle Fish is Assistant Professor of polymer and inorganic chemistry at St. Vincent College in Latrobe, PA. He received B.S., M.S., and Ph.D. degrees from the State University of New York. His research interests include new ways of synthesizing plastics and space aged materials and controlling their physical properties. His research also includes environmental chemistry of iron compounds as it relates to remediation of mine drainage. His work also focuses on passing on skills to students with one-on-one and small group research projects. He enjoys playing with his two sons, fly fishing, and gardening.

Wednesday 12:40 - John Chermak

Water Quantity and Water Quality Considerations for Cost-Effective Acid Rock Drainage Water Treatment

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Abstract
Evaluation of water treatment options for acid rock drainage (ARD) impacted water depends on both water quantity and water quality. It is well-known how difficult and expensive it is to treat the large volumes of ARD-impacted streams typically found in mining regions. Treatment costs are also a function of the initial water quality and the desired water quality that needs to be achieved. One of the biggest challenges for successful and cost-effective treatment of these types of waters is that there is generally insufficient iron (less than 25 mg/L) present in the low total dissolved solids (TDS) waters to get nucleation and precipitation of iron oxyhydroxide after neutralization within a reasonable time frame. It is also difficult to maintain a stable solution pH value. We have found that these chemical limitations can be overcome by adding small quantities of neutralized high TDS, high dissolved iron water to the low TDS water. The high TDS water provides enough iron in solution to promote nucleation, growth, and production of adequate size floc. The ARD treatment system to be discussed is located in Eastern Tennessee and investigations started with laboratory neutralization experiments followed by a pilot scale plant, and ultimately the construction of a cost-effective full scale hydrated lime neutralization plant at the base of a 9,000-plus acre watershed. Average removal efficiencies of aluminum, cadmium, cobalt, copper, iron, lead, and zinc from the stream water were greater than 95% and concentrations achieved were lower than applicable ecological standards.

Biography
Dr. John Chermak is currently an Environmental Scientist and instructor in the Geosciences Department at Virginia Tech. He received a PhD in Geology (Geochemistry emphasis)from Virginia Tech in 1989, spent 3 years in Switzerland working on applied environmental issues related to Rad-waste disposal, taught and conducted research at Georgia State University for 1 year, and has worked as an Environmental Scientist/Geochemist consultant to industry since 1993 on projects in 18 different states and 9 different countries. He is a certified Professional Geologist in the states of Virginia and Wyoming.
Areas of expertise related to mine sites include water quality and quantity issues, waste rock, tailings, pit lakes, and water treatment alternatives.
He has published more than 10 papers in refereed journals on various aspects of applied environmental issues.

Wednesday 1:10 - Griff Wyatt

North Potato Creek In-Pit Water Treatment Plant at the Copper Basin Mining Site

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Abstract
To protect the Ocoee River from acidity and metals loadings from historical copper mining activities, OXY USA is conducting removal actions to alleviate contaminant discharges from North Potato Creek (NPC). One such action is construction of an innovative in-pit lime treatment facility at the South Mine Pit (SMP) designed to treat variable NPC flows ranging from dry weather flows of 9 cfs to a 10-yr, 24-hr storm of 972 cfs for 15% of the cost of a conventional lime treatment plant. The treatment facility utilizes high dissolved solids water from the lower portion of the stratified SMP as seed water to enhance flocculation of iron precipitates and the large surface area of the SMP as a settling basin. The in-pit lime treatment facility operates in the following manner. A portion of the flow is pumped from NPC to a rapid mix tank (RMT) where lime slurry, air, and high dissolved solids water from the pit are added. The RMT discharge flows back into NPC where it mixes with the remainder of the NPC water and ultimately discharges into the 20 acre SMP. The SMP provides an effective settling basin for the precipitated solids from the NPC flow. The in-pit plant operations began in January 2005 and early results show that reductions in dissolved metals loading of 650 lbs per day to the Ocoee River are being achieved.

Biography
Griff Wyatt is a Senior Environmental Engineer and Project Manager with Barge, Waggoner, Sumner, and Cannon in Nashville, Tennessee. He earned his Bachelor's Degree in Civil Engineering and Master's Degree in Environmental Engineering from Vanderbilt University. He is a registered engineer in Tennessee, Florida, and Indiana. He has worked in environmental consulting for 26 years and has been working on the environmental restoration program at the Copper Basin Mining District site for the last four years.

Wednesday 1:40 - Dan Mueller

Overview of Steel Slag for Mine Drainage Remediation

Author(s)

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Abstract
Acid mine discharge water treatment using slag sources from across North America have seen widespread application principally because its alkaline nature and low cost. The application of slag for neutralization of acidic streams competes with well crushed limestone and residual products such as fly ash. Nearly all of the slag generated for this use in North America is produced from the production of iron and steel. Slag from blast furnaces, basic oxygen furnaces and electric furnaces all have different qualities and characteristics that can impact the application of slag for acidic wastewater treatment. This presentation will shed some light on the different types of slag production methods and describe the selection of slags for treatment of acidic mine wastewaters and why some sources are better than others.

Biography
Daniel Mueller is Manager of Product Development for Recmix of PA, Inc. a wholly owned subsidiary or Excell Minerals, Inc located in Pittsburgh PA. Recmix de-mineralizes stainless steel slag producing pure stainless steel and fine ground slag. Mr. Mueller has been with Recmix for 6 years and has extensive experience with mine reclamation with slag products. Mr. Mueller has a Chemical Engineering degree from the University of Pittsburgh and has been working in the environmental remediation and restoration fields for 20 years as a consultant and product manager.

Wednesday 2:50 - Sean C. Muller

Utilization of High Sulfur Coal for Selenium Removal in Phosphate Mine Waters

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Abstract
Selenium is mine waters and soils has recently been an issue for phosphate producers in southeastern Idaho. Carbonaceous shale beds proximal to phosphate bearing beds in the Phosphoria Formation liberate oxidized selenium to pit water, surface water and mine soils in quantities that are acutely toxic to sheep and horses when concentrated naturally in vegetation or consumed directly as stock water. In order to deal with the selenium toxicity problem, the phosphate mining companies have evaluated several treatment technologies, both active and passive for selenium removal and stabilization. One passive technology that holds promise is the active treatment of water and the passive treatment of soils and tailings using high sulfur coal. Another technology that is under evaluation is the treatment of selenium-enriched waters with low selenium apatite from phosphate mines in Utah. This paper will present the results of column testing to compare the efficiencies of high sulfur coal and selenium deficient phosphate ore for selenium removal from pit water from an inactive mine. A pilot scale tailings application of both media is planned for an active mine this summer. Detail regarding this proposed field application will also be presented.

Biography
Sean Muller has over 30 years of industry and consulting experience. His technical specialties include forensic geochemistry, mine lands remediation and new technology development. He has a bachelors in Earth Science/Biology from LaSalle University and a Masters in Geology from Idaho State University. He currently works for AquAeTer as the director of the Mining Group.

Wednesday 3:20 - Jack Adams

Biological Selenium and Arsenic Reduction: An Overview

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Terrence D. Chatwin, Ximena Diaz, Jan D. Miller, University of Utah

Abstract
Selenium and arsenic are common contaminants worldwide. Selenium is periodically related to sulfur and like sulfur, positively charged selenium forms soluble oxyanions. The chemical characteristics of selenium and arsenic are dominated by the fact that they readily change oxidation states or chemical form through chemical or biological reactions that are common in the environment. Selenium most commonly occurs in four oxidation states: SeO_4^{2-}, $SeO_3^{\ 2-}$, Se^0, & Se^{2-}. Well aerated, alkaline surface waters contain the majority of selenium as selenate. Negative and zero valences are associated organic and elemental selenium while positive valences are associated with mineralogy and aqueous systems, with selenate being more mobile than selenite. The EPA maximum contaminant level (MCL) for selenium in drinking water is 50 parts of selenium per billion parts of water (50 ppb) and a maximum contaminant level goal (MCLG) of 20 ppb. Recommended levels for aquatic wildlife is 2 ppb. Arsenic may occur as a semi metallic element (As^0), arsenate (As_4^{3-}), arsenite (As_3^{3-}), or arsine (H_3As). Arsenate is the oxygenated pentavalent form of arsenic and is the most abundant species in oxygenated waters. The Environmental Protection Agency (EPA) has established a Maximum Contaminant Level (MCL) of 50 µg/L for arsenic in drinking water; this value will change to a 10 ppb national standard in 2006. Both selenium and arsenic are difficult to remove to levels that meet current drinking water and discharge criteria. They are used as electron acceptors by microorganisms transforming them to reduced states, thus removing or stabilizing them. Many of these metal transformations are coupled with the cytochrome system and are an energy source under anaerobic conditions.

Microbial selenium transformations have been investigated for decades and have been found to be a common occurrence; microbial reduction of arsenic has not been studied as extensively. Microbes responsible for selenium and arsenic reduction have been isolated from contaminated mining process and waste waters, mining waste rock materials, agricultural soils and drainages, petroleum refining and coal fired power generation wastewaters, and domestic wastewater treatment facilities. Selenium and arsenic reducing microbes can be found in numerous genera including Alcaligenes, Escherichia, Pseudomonas, Bacillus, Desulfovibrio, Shewanella, Enterobacter, Thauera, and numerous genera within Cyanobacteria and the sulfate reducing bacteria. Metal and metalloid reducing microbes are quite biquitous and can be cultured from environmental samples using common techniques. Some microbes are capable of direct selenium reduction under aerobic conditions by metal-active enzymes, possibly a detoxification mechanism. Similar reductions are thought to occur among some of the arsenic reducing microorganisms.

Fundamental considerations are important for successful application of selenium and arsenic biological treatments and involve several steps starting with site characterization, bioassessment and biotreatability testing, and biotreatment monitoring. While many microbes are capable of selenium and arsenic reduction, specific site environmental characteristics need to be taken into consideration for optimal metalloid reduction at any specific site. In general, biotreatments typically produce 1,000's of times less sludge than conventional precipitation technologies and can be employed in several basic ways:

- Biostimulation through addition of nutrients that stimulate most or many of the site indigenous microbes
- Biostimulation through isolation of key site microbes, production of these microbes followed by reintroduction of this population back into the treatment system
- Bioaugmentation or the introduction of new microbes, possibly microbes already present at the site, but known to have the biochemical systems needed to transform the contaminant form present and have high transformation efficiencies
- Bioaugmentation/Biostimulation or a combination of both techniques that leads to a population of both new and indigenous microbes.

Selenium and arsenic reduction/sorption has been demonstrated in various waters with live microbial cells, microbial biomaterials, enzymes, and proteins that have a high affinity for these metalloids. These biomaterials can be immobilized and have been shown to rapidly reduce or sorb selenium and arsenic and various other metals and inorganic contaminants from various environmental waters.

Biography
Dr. Adams' background is in molecular and applied environmental microbiology and environmental engineering. He has worked in environmental biotechnology for about 30 years for state & federal government agencies and industry. Dr. Adams' headed U.S. Army and U.S. Bureau of Mines Biotechnology Programs, directed the Bioremediation Center at Weber State University and is the current director of the Modified & Activated Carbon Technology Center at the University of Utah.

Wednesday 3:50 - Roger Bason

Hydropower Revenues for Acid Mine Drainage (AMD) Clean-Up

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Abstract:
The revenue from hydropower generation captured in water flows from the Jeddo Tunnel near Hazelton, PA is proposed for regional clean up and remediation activities facilitated by the Eastern Middle Anthracite Region Recover, Inc. (EMARR). The Eastern Middle Anthracite Region (EMAR) constitutes four (4) counties: Carbon, Columbia, Luzerne and Schuylkill. The creeks located within EMAR (e.g. the Black Creek, the Nescopeck Creek and others) have been severely contaminated due to Acid Mine Drainage (AMD). Over thirty-four miles of streams and rivers in the EMAR region are impacted by AMD (3,000 miles statewide) that render steams devoid of fish and severely impact aquatic ecology as well as a variety of uses ranging from agriculture, irrigation, real estate values, public health concerns, scenic interest and a full spectrum of recreational activities. The Jeddo Tunnel drains water from EMAR coal fields at rates greater than 40,000 gal-min. With a pH in the range of 4.5 to 5.5, the Jeddo Tunnel is the largest point source of pollution in the Susquehanna River Watershed. While this critical and persistent problem can be solved by a set of known remediation strategies, a key factor is how to pay for the on-going remediation of streams that require constant input of such materials to neutralize rainfall resultant acid waters over time. This project presents a design – build scenario for an initial 100 kW hydroelectric unit using an innovative solution that provides for small hydropower generation from the water flowing from the Tunnel drainage. It presents a model system that can be applied to many impacted areas throughout the state. A preliminary study indicates 24 additional hydro sites within the four county area (Carbon, Columbia, Luzerne, Schuylkill) that represent a potential hydroelectric output of over 2MW or approximately 14,000 MW hours per year.

Biography
Roger Bason, (President of Natural Currents for Pennsylvania, LLC, a subsidiary of E3, Inc.) has directed twelve significant tidal and technology related projects over the past five years. These projects have involved the generation of clean hydro and tidal power using cutting edge In-Stream and Cross Flow technology. In addition, Mr. Bason has worked closely on energy analysis projects for the United Nations Headquarters in Manhattan (2000) and the United States Postal Service (1997-98) in cooperation with NYSERDA. Mr. Bason has also taught tidal power courses at the Center for Energy, Marine Transportation, and Public Policy, School of International and Public Affairs, Columbia University and currently teaches and coordinates an on-going research program at SUNY Maritime College.

Dr. Igor Yatskar, (Vice-President/Technology Development of E3, Inc.) has worked closely with several public utilities in New York, Massachusetts and Florida to provide a wide variety of analytical services including tidal power development, rate evaluations and tidal power systems design. Dr. Yatskar directed the efforts to interpret the relationship between the water speed and the power generation for innovative hydro projects that include Acid Mine Drainage, Waste Water Treatment Plants, rivers, canals and tidal systems. He has accomplished highly sophisticated analyses that present cutting edge interpretations of hydropower analysis into graphical presentations understandable by all.

Wednesday 4:20 - Mark B. Carew

Passive Treatment of Acid Mine Drainage with Open Limestone Channels in the Lower Rock Creek Watershed

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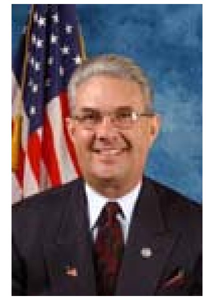
Abstract
Acid mine drainage (AMD) from over 40 coal mine portals and eight pyrite-rich coal processing refuse dumps had decimated aquatic life in the lower Rock Creek watershed and rendered the stream virtually lifeless. Water quality data was analyzed from 41 portals and seeps in the study area. Acid and metal loading was calculated for each portal and passive treatment options were explored using the water chemistry analysis for each portal discharge. Water and biological monitoring were conducted in the watershed to document improvements in the watershed. In the fall of 2000 construction began on a reclamation project targeting several of the worst AMD sites in the lower Rock Creek watershed. As part of the reclamation project open limestone channels were installed routing AMD through the limestone before discharging into the stream. Reclamation continued in the fall of 2002 with the installation of additional open limestone channels routing AMD from mine portals to the receiving streams. Limestone channel lining was placed directly into four severely impacted tributaries of Rock Creek, treating the AMD in the tributaries before it enters Rock Creek. Over 20,000 feet (6096 meters) of open limestone channels have been installed in the lower Rock Creek watershed. Significant reductions in acidity and dissolved metal concentrations have occurred in the tributaries being treated with open limestone channels. Water quality in Rock Creek has improved, with fish populations rebounding with increases in numbers, diversity of species, and numbers of intolerant species.

Biography
Mark Carew is a registered geologist with the Kentucky Division of Abandoned Mine Lands. Mark received his Bachelor of Science and Master of Science degrees in geology from Eastern Kentucky University. He has over 20 years of field experience in the coalfields of Kentucky including 17 years with the Kentucky AML program.

Thursday 8:00 Congressman John E. Peterson



Keynote Address

A Bipartisan Bill to Accelerate Clean-Up Of Hazardous Abandoned Coal Mines

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Biography

John Peterson is a lifelong resident of western Pennsylvania, born in Titusville on Christmas Day 1938, and for years a resident of nearby Pleasantville. He served in the U.S. Army, both in active and reserve duty, from 1957 through 1963.

After the army, he came back home to Western PA looking to start a business, and, after years of scrounging up the necessary seed money, was able to buy a local grocery store. He would own and operate that food market for over 25 years.

His public service career started way back in the 70s when he served on his local hospital board and ran for a seat on his local borough council, which he won and kept for eight years. In 1977, he was approached to run for the Pennsylvania State House of Representatives, which, of course, he did.

The rest, as they say, is history. John served in the State House for 8 years, and, in 1984, was elected to the Pennsylvania Senate where he chaired both the Public Health and Welfare Committee and the Republican Policy Committee. While in the legislature, Peterson authored the Welfare Reform, Living Will, and AIDS Confidentiality legislation.

In 1996, Peterson was elected to Pennsylvania's Fifth Congressional District in the U.S. House of Representatives. Upon arrival he was asked to serve on the Education and Workforce Committee, where he brought attention to issues related to technical and career education and worked to make higher education of all types more accessible to average Americans.

Today, he sits on the powerful House Appropriations Committee and its Subcommittee on Labor, Health and Human Services and Education, as well as the Interior and Environment Subcommittee, which, among its duties, oversees funding for abandoned mine lands. He also serves on the House Resources Committee, where he is a member of the Forests and Forest Health Subcommittee and the Subcommittee on Energy and Mineral Resources.

As Co-Chairman of the Congressional Rural Caucus, John has worked with legislators of all stripes to strengthen and revitalize rural communities through initiatives that create jobs, develop local economies, and keep rural folks safe and healthy.

Of course, a major impediment to rural development and public safety is the continued danger that abandoned mines pose to rural communities. That's why Congressman Peterson is committed to reducing the health, safety and environmental hazards of abandoned coal mines left over from decades of unregulated mining. He is author of House Resolution 2721, a commonsense piece of legislation that would reauthorize the Abandoned Mine Land Reclamation Fund, and readjust the funding formula so that states with the worst outstanding mines get the funds they desperately need, and, frankly, rightfully deserve.

Peterson is married to Saundra, his wife of over 30 years. They have a son and two granddaughters.

Thursday 8:30 - Scott F. Sibley

Market Trends in Metals Supply and Demand - Recent Rises in Metal Prices

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Abstract
With the dramatic rises in metal prices in 2004, spanning nearly the full spectrum of metals sold commercially, questions have arisen about the causes of these increases. The basic supply of metals is discussed, and the various reasons for metal price rises, for the purpose of identifying the most important causes of these relatively high price levels. Some examples of historical demand and price trends are given for aluminum, manganese, and iron ore, along with specific examples of trends in aluminum, steel, and iron ore in China. Suggestions of possible outlets for recovered metal-bearing material from mine water drainage are also given.

Biography
Scott F. Sibley has spent his entire career of more than 30 years with the U.S. Government in the minerals information field, working first at the U.S. Bureau of Mines, specializing in cobalt and nickel, and serving in a supervisory capacity in the ferrous metals area. When the Bureau of Mines was closed by Congress in 1996, the minerals information function was transferred to the U.S. Geological Survey, and he continued supervision of ferrous metals specialists, becoming Chief of the Metals Section, Minerals Information Team, in 2004. Mr. Sibley holds a Bachelor of Science degree in Geology from Principia College in Illinois and a Master’s degree in Earth Sciences from Washington University, St. Louis, MO.

Thursday 9:00 - Charles A. Cravotta III

Relations among pH, sulfate, and metals concentrations in Anthracite and Bituminous coal-mine discharges, Pennsylvania

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Abstract
Water-quality data for discharges from 140 abandoned underground mines in the bituminous and anthracite coalfields of Pennsylvania illustrate relations among pH, sulfate, and dissolved metal concentrations. The pH for the 140 samples ranged from 2.7 to 7.3; with two modes at pH 2.5 to 4 (acidic) and pH 6 to 7 (near neutral). Although the pH distribution was similar for the bituminous and anthracite discharges, the bituminous discharges had smaller median flow rates and greater concentrations of sulfate, iron, aluminum, and various other metals than anthracite discharges with the same pH values. The observed relations between the pH and metals concentrations can be attributed to (1) dilution of acidic water by alkaline ground water; (2) solubility control of aluminum, iron, manganese, barium, and lead by hydroxide, sulfate, and/or carbonate minerals; (3) adsorption control of arsenic and selenium; and (4) formation of aqueous complexes between dissolved metals and sulfate ions. The formation of aluminum-sulfate complexes can account for 10 to 100 times greater concentrations of dissolved aluminum in bituminous discharges compared to anthracite discharges at similar pH. The complexes add to the total dissolved aluminum concentration at pH of equilibrium with aluminum hydroxide or hydroxysulfate minerals. In contrast, bituminous discharges have lower lead and barium concentrations than anthracite discharges indicating elevated sulfate concentration decreases solubility of these metals. These general relations and processes as described for underground abandoned mine discharges are applicable to the understanding of drainage from surface coal mines and metal mines and of reactions during acidity titrations and treatment of mine drainage.

Table 1: Composition of discharges from abandoned coal mines in Pennsylvania, 1999 [median(min;max)]

Coalfield & number of samples	**Flow Rate**	**pH**	**Oxygen**	**Sulfate**	**Iron**	**Manganese**	**Alumnum**
	(m^3/min)		**(mg/L)**				
Anthracite N=41	3.84	5.1	1.9	260	15	2.9	0.28
	(0.01;132)	(3.0;6.3)	(0.3;11.1)	(34;1300)	(0.046;312)	(0.019;19)	(0.007; 26)
Bituminous N =99	0.75	5.2	0.6	580	43	2.3	1.5
	(0.01; 16.7)	(2.7;7.3)	(0.2;11.5)	(120;2000)	(0.16;512)	(0.12;74)	(0.008; 108)

Coalfield & number of samples	**Arsenic**	**Selenium**	**Yttrium**	**Barium**	**Lead**	**Nickel**	**Zinc**
	(mg/L)						
Anthracite N=41	0.62	0.4	2.9	18	0.68	83	130
	(<0.03;15)	(<0.2;3.9)	(0.18;44)	(13;31)	(<0.1;11)	-19,620	(3.0;1000)
Bituminous N =99	2	0.6	15	13	0.1	90	140
	(0.1; 64)	(<0.2;7.6)	(0.11;530)	(2.0;39)	(<0.1;4.6)	(2.6;3200)	(0.6;10,000)

Biography
Dr. "Chuck" Cravotta is a research hydrologist at the U.S. Geological Survey Pennsylvania Water Sciences Center and adjunct Assistant Professor of Environmental Engineering at Penn State Harrisburg. He received his B.A. in Environmental Sciences from the University of Virginia and his M.S. and Ph.D. in Geochemistry and Mineralogy from the Pennsylvania State University. His research emphasizes field and laboratory applications of geochemical and hydrological methods for the characterization and treatment of drainage from coal mines.

Thursday 9:30 - Michael R. Silsbee

A Novel Corrosion Inhibitor for Steel in Concrete Derived from Acid Mine Drainage Sludge

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Abstract
Acid Mine Drainage (AMD) degrades the quality of water over wide areas of Pennsylvania, West Virginia and Maryland. A common method for dealing with AMD is to neutralize the acid using calcium. Corrosion of steel-reinforced concrete is a major factor that degrades infrastructures. Pennsylvania has more bridges than any other state, hence its highway system is particularly susceptible to the effects of corrosion. Based on a technology developed by Chemydration, LLC, RJ Lee Group, Inc. has confirmed that sludge from (AMD) can serve as a raw material for a corrosion inhibitor that materially increases the service life of concrete. While the composition of the corrosion inhibitor is proprietary, it acts to intercept chloride before the chloride can reach the reinforcing steel and facilitate corrosion. For this reason the inhibitor exhibits performance superior to presently available corrosion inhibitors, such as calcium nitrite. This presentation will discuss aspects of processing the sludge as a raw material, pyro-processing of the sludge to manufacture the corrosion inhibitor and the performance of the corrosion inhibitor in concrete. A preliminary design for a manufacturing facility will be described. Initial estimates show that the market for this corrosion inhibitor in new construction alone could exceed 20,000 tons per year. Dewatered AMD sludge typically has a 20 wt. % solids content translating to 100,000 tons of dewatered sludge consumed each year. The market in repair and rehabilitation has been conservatively estimated as 10 times as large. Thus, production of the corrosion inhibitor potentially offers a large volume use for AMD sludge.

Biography
Dr. Michael Silsbee assists with the ongoing efforts to develop new products for the construction industry at RJ Lee Group, Inc. He manages projects involving the evaluation of construction materials, mainly focusing on concrete related projects. Previously, Dr. Silsbee had managed the laboratory facilities at the Materials Research Laboratory at Penn State University. He has worked for the past twenty years investigating cementitious and ceramic materials, which include various techniques to characterize powders. In 1996 Dr. Silsbee and a colleague at Penn State developed an approach to dealing with acid mine drainage that allowed a Pennsylvania firm to win a Governor's Award for Environmental Excellence. Their work on acid mine drainage abatement was a key factor in Tobyhanna Army Depot winning a Secretary of Defense Environmental Security Award in 1996. More recently Dr. Silsbee was part of the commonwealth's dirt and gravel road task force that won a second Governor's award for Environmental Excellence in 2000. Dr. Silsbee also established and served as the first director of the Dirt and Gravel Road center at Penn State. Dr. Silsbee holds a BS degree in Ceramic Engineering from Alfred University and a PhD degree in Solid State Science from Pennsylvania State University.

Thursday 10:30 - Lykourgos Iordanidis

AMD Treatment Sludge as Raw Material for the Cement Industry

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Abstract
Typical Portland cement may contain up to 6 wt. % Fe_2O_3 as part of its chemistry. The iron content of the cement is important for maintaining the proper chemistry during the sintering of the cement. This paper will discuss the potential use of AMD treatment sludge for use in the manufacture of Portland cement. Important factors when considering the sludge chemistry will be presented. Logistics and handling issues will be discussed. The results of a preliminary assessment of the feasibility of this approach, including associated costs, will be presented.

Biography
Dr. Lykourgos Iordanidis is currently one the managers of the Chemistry Department at RJ Lee Group, Inc. Previously as a Senior Scientist at RJ Lee Group, Inc he was involved in the R&D of concrete additives and the development of analytical methods related to specific projects. Dr. Iordanidis' initiation with the RJ Lee Group was in the sampling supervision, processing, interpretation and data presentation in the largest environmental study ever performed on a lower Manhattan building impacted by the collapse of the World Trade Center. Dr. Iordanidis holds a BS degree in Chemistry from the Aristotelian University of Thessaloniki, Greece and a PhD degree in Inorganic/Solid State Chemistry from Michigan State University. His post-doctoral studies took place at the University of Michigan. During his PhD thesis and postdoctoral studies his research involved several different classes of materials. He investigated the synthesis and characterization of relatively unknown semi-conducting bismuth chalcogenides for their potential as promising thermoelectric materials, as well as the synthesis and characterization of molecular compounds with potential anticancer activity and multimetallic clusters with redox properties. He has also conducted research in the area of porous and extended inorganic and organic solids. He has become experienced with a variety of X-ray diffraction, spectroscopic, thermal, microscopy and other materials characterization techniques.

Thursday 11:00 - Mark Conedera

Applications of AMD Sludge for the Steel Industry

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Abstract
Because acid mine drainage (AMD) sludge contains iron in an oxide rather than metallic form, its potential use in integrated steelmaking is limited to iron production in blast furnaces. In order to charge AMD sludge into a blast furnace, it must first be agglomerated. Accepted agglomeration methods include pellitizing, sintering, and briquetting. The United States Steel Corporation (U. S. Steel) Edgar Thomson Plant located in Braddock, Pennsylvania has the last two operating blast furnaces in the state of Pennsylvania and utilizes a briquetting plant to agglomerate fine materials containing iron oxides for subsequent charging into the blast furnaces. A sample of AMD sludge provided to U. S. Steel by the Pennsylvania Department of Environmental Protection was evaluated as a potential feed material to the Edgar Thomson Plant blast furnaces. The iron content of the sample proved insufficient to justify its use. In addition, other metallic components of the sludge were at concentrations detrimental to the steelmaking process. Based on a technical analysis conducted by U. S. Steel Research personnel, use of AMD sludge in blast furnaces cannot be justified unless the total iron content is greater than about 55% and the sulfur content does not exceed 0.1%. More sulfur can be tolerated provided that the total iron content exceeds 55%. The economic value of suitable AMD solids will depend on the actual cost of agglomeration. For the Edgar Thomson Plant briquetting facility, AMD sludge impacts on drying costs, binder costs, and briquette plant productivity must be evaluated. The physical and metallurgical properties of the briquetted product must also be considered. Continued evaluation of AMD sludge for steelmaking will require both laboratory and full-scale plant testing.

Biography
Mark Conedera is a Senior Environmental Engineer in the corporate Environmental Affairs Department of United States Steel Corporation (USS), Pittsburgh, Pennsylvania. In his position, he is responsible for managing the corporate Hazardous Materials Storage and Toxics Release Inventory (TRI) reporting programs. These programs were mandated under the federal Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and expanded by the Pollution Prevention Act of 1990. In addition, Mark is the liaison between the Environmental Affairs Department and Research Division of USS for projects involving the use of steelmaking byproducts. Prior to his current position, Mark held positions in the Environmental Control Departments of the USS Edgar Thomson Plant and Gary Works and has been with USS for over fourteen years. He holds a B.S. degree in Environmental Engineering from Pennsylvania State University and M.S. degree in Civil Engineering from Carnegie Mellon University, and is a registered Professional Engineer in Pennsylvania.

Thursday 11:30 - Barry Scheetz

Self-lubricating Bearings Fabrication Using Recovered Iron Oxide

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Abstract
Metal parts fabricated by pressed and sintered powders are stronger, more durable and more easily fashioned into complex shapes than similar materials cut from preformed metal. These advantages along with the elimination of most of the waste from machining metal parts make powdered metal fabrication very economically attractive. This talk will describe preliminary efforts to utilize an alternative source of iron oxide derived from treatment of AMD as input feed stock into this process. The initial characterization of the fabricated parts suggest the use of chemically precipitated nano-particles of iron oxyhydroxide and gypsum form what can be described as a particle strengthened metal matrix composite material with chemical, mechanical, and performance properties that, when optimized, could offer a significant economic alternative material in the market place.

Biography
Barry E. Scheetz, Professor of Materials, Civil and Nuclear Engineering, has been a faculty member at the Pennsylvania State University for 30 years. During this time, Professor Scheetz has focused his research on a variety of environmental issues concerning nuclear waste disposal and the utilization/reutilization of industrial waste materials, so-call "cast-off materials". A significant portion of his research activities has centered on mineland reclamation. Recent programs have been utilizing fly ash and alkaline waste activators to fabricate non-traditional alkali-activated cements for large volume use in environmental restoration. Professor Scheetz holds approximately 40 combined U.S. and foreign patents and is the author of 200 scientific publications. He has served on numerous National Research Council committees.

Thursday 1:25 - William Benusa

Metallurgical Evaluations of AMD Sludges

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Abstract
As part of the Pennsylvania Department of Environmental Protection (DEP) Abandoned Mine Reclamation Grant Program to the Southern Alleghenies Conservancy (SAC) a program (Resource Recovery Phase 3) was executed to promote the recovery of mineral resources from abandoned mine drainage treatment. The Grant was being used to fund various projects, of which Concurrent Technologies Corporation (CTC) was tasked to conduct a metallurgical evaluation of selected acid mine drainage (AMD) treatment residuals. The SAC worked with CTC to identify eight different AMD treatment residuals to evaluate for the potential use in self-lubricating bearing materials. CTC evaluated these materials by first conducting a materials characterization of all eight samples. Then, based on those results and discussions with St. Mary's Pressed Metals, two samples were selected for powder consolidation and mechanical testing to determine if in fact the AMD residual materials were suitable for bearing applications. This presentation will discuss the conclusions from the evaluation.

Biography
Mr. Benusa is a Senior Environmental Specialist in the Environmental & Energy Programs Group at Concurrent Technologies Corporation (CTC). At CTC, his responsibilities include managing and technically supporting multiple environmental and manufacturing projects. Mr. Benusa's background includes numerous years of industrial environmental experience spanning a broad range of technical and management functions, including brownfield development, watershed management, EH&S compliance auditing, pollution prevention, and permitting. He holds a B.A. in Environmental Science from Thiel College.

Mr. Benusa also is a founding member of the Plum Creek Watershed Association; he currently servers on the Board of Directors as Treasurer. Plum Creek Watershed is a four year old, non-profit (501c3) Association and is currently completing their Stream Protection and Restoration Plan with monies obtained from a PA DEP Growing Greener Grant.

Thursday 1:55 - Mike Sawayda

Using Iron Oxides in Brixx©

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Abstract

There are currently more than 88 million tons of fly and bottom ash produced by coal fired electrical generation in the United States. Only 45% of this material is beneficially used, leaving nearly 53 million tons of ash unused and requiring landfilling at a cost to the electric utilities. Pittsburgh Mineral & Environmental Technology (PMET) has developed an innovative, patented Brixx Technology at the pilot plant scale to utilize additional fly ash. This process produces saleable building products by combining lime with fly and bottom ash, producing a product that is made of 90% recycled materials. PMET Brixx are stand-alone products, saleable to consumers and unlike some concrete applications, can utilize fly ash with an LOI exceeding 3%. After mixing the required components, desired shapes are pressed and a hydrothermal cure forms tobormorite crystals in the Brixx, creating a strong building product. Shape examples include rectangular, hollow-section, and interlocking blocks. Colored products are produced by adding pigments to the mixture or applying coatings to the finished products. PMET will also investigate whether AMD sludge can be used as a pigment.

PMET has demonstrated this technology in an Energy Harvest Grant sponsored by the Pennsylvania Department of Environmental Protection (DEP). Brixx were demonstrated to be 54% stronger than commercially available pavers and pass ASTM standards for pavers. Additionally, PMET demonstrated that this technology will utilize between 3.5 and 10.5 times less energy and emit 50% less CO_2 than traditional clay brick production.

To commercialize the technology, PMET is seeking a joint venture partner. For the commercialization effort, PMET will license the technology to the joint venture company and provide the required technical support. PMET is seeking a partner(s) that is able to provide capital to construct a plant, is willing to operate the plant, and has the knowledge and infrastructure for marketing and distribution of building products.

The first commercial Brixx plant is expected to produce approximately 13.5 million pieces per year, about half the size of an average brick plant. A paver product is projected to exhibit a direct cost of less than $0.11 per piece and to be saleable at $0.25. The installed capital of such a plant is expected to be $2.2 million. For a partner that is providing the capital for a 50% share in the venture, PMET expects an Internal Rate of Return (IRR) of 33% and a Net Present Value (NPV) of this investment at $5.3 million.

Biography

Michael Sawayda is currently a Senior Process Engineer with a background in chemical engineering and experience in both research and manufacturing. He has coordinated and developed various pilot plant operations, including a process at PMET to produce low-cost hydrogen and one demonstrating PMET's patented Brixx process. In addition, he develops computer models of mass and energy balances and thermodynamic equilibria to prepare processes for scale-up. He received both B.S. and M.S. degrees in Chemical Engineering from Case Western Reserve University.

Thursday 2:25 - Susan J. Tewalt

Mn Recovery from Ozone Technology in Mine Water Treatment

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Kristin O. Dennen

Abstract
Manganese is an aesthetically undesirable metallic element that is difficult to remove from acidic to neutral pH mine drainage. In spite of the thermodynamic prediction that oxygen should oxidize dissolved manganese (Mn^{2+}) to an oxide or a hydroxide, this does not happen. Bench-scale experiments at U.S. Geological Survey (USGS) labs have documented the capability of ozone to oxidize and precipitate dissolved manganese to manganese dioxide. The process was granted U.S. patent no. 6,485,696. The USGS installed a pilot-scale ozonation system at the Little Toby Creek Treatment Plant in Elk County, PA, which is a limestone-based acid mine drainage treatment plant operated by the Pennsylvania Department of Environmental Protection. Ten pairs of limestone-treated mine drainage water samples, collected in 2004 prior to and following ozone treatment, were analyzed. Measurements of Eh-pH values in the water samples subjected to ozone treatment demonstrate a shift from the Mn^{2+} field into the manganese dioxide (Mn^{4+}) stability field. Dissolved concentrations in the treated effluent were lowered by 98 percent for manganese, by 99 percent for iron, by 78 percent for cobalt, and by 8 percent for nickel. The precipitate is generally sub-micron in size; the current bag filter system provides incomplete capture. Installation of a sedimentation pond would likely increase recovery of the MnO_2. The pilot-scale system can generate 8 pounds of ozone per day and treat a flow of 30 gallons per minute. A new mine drainage site with high Mn^{2+} and low iron concentrations is being sought for possible installation of the system.

Biography
Susan Tewalt is a geologist who has worked in coal quality, resource estimation and mining issues concerning coal utilization for the past 30 years. She worked on Gulf Coast coals for 8 years, including 2 years at the Surface Mining and Reclamation Division of the Railroad Commission of Texas. Susan joined the USGS in 1987 and since late 2001 has spent part of her time working on the ozone remediation of manganese in mine drainage water.

Thursday 3:25 - Robert S. Hedin

Successful Production of a Marketable Iron Product from Mine Drainage Sludge

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Abstract
In 1994 Hedin Environmental received a Small Business Innovation Research award from the US Department of Agriculture to investigate the feasibility of producing useful products from iron-rich mine drainage sludge. The investigation determined that passive treatment processes could produce an 85-95% pure iron oxide solid and also identified existing markets for iron oxides in metal, water treatment, catalyst, magnetic, and pigment industries. The most promising market proved to be the pigment market. In 1999 an opportunity developed to recover about 1000 tons of 80-90% pure iron oxide from an abandoned deep mine site in southwestern PA. A pigmentary customer was identified who required a 50% solids, clean product. R&D support was received from the PADEP, OSM's Resource Recovery Program, and the Heinz Endowments. Between 2000 and 2003, a saleable product was produced by a variety of recovery, dewatering, and screening methods. The most efficient production method involved pumping, wet screening, and dewatering with frame filter presses. The least costly production method involved excavation, passive dewatering, and dry screening. In 2003 and 2004, production occurred at three new sites, all of which were passive treatment systems where excessive iron sludge accumulation had decreased performance. Unfortunately, not all mine drainage treatment systems yield pigment-quality iron oxides. Iron sludges formed under acidic conditions or ones formed where oxidation is accelerated by chemical or physical means generally have poorer pigment characteristics and, at this time, are not marketable as pigments. Other uses for these iron sludges are being investigated. The presentation will describe the recovery of pigment-quality iron oxide and provide information on investigations into other uses.

Biography
Bob Hedin has a Ph.D. in Ecology from Rutgers University where he studied plant communities and soils on abandoned mine sites in western PA. Between 1987 and 1994, he was a research biologist with the US Department of the Interior, Bureau of Mines. His work involved the geochemistry of mine drainage and passive treatment of coal mine drainage. In 1994, Bob left the Bureau of Mines and formed Hedin Environmental. The small firm specializes in the assessment and remediation of polluted coal mine drainage, primarily by passive methods. One of the firm's first projects was an investigation of the feasibility of producing a saleable product from mine drainage sludge. This project eventually resulted in the formation of Iron Oxide Recovery, Inc, a company whose primary purpose is the profitable production of iron oxide products and the design/construction of treatment systems that produce saleable iron oxides.

Thursday 3:55 - Chad J. Penn

Effectiveness of AMD Residuals in Reducing Phosphorus Concentrations in Runoff from Agricultural Soils

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Abstract
Prevention of phosphorus (P) losses from agricultural land to surface waters is critical to water quality issues such as eutrophication. Residual materials resulting from acid mine drainage (AMD) neutralization were evaluated for their ability to reduce available P concentrations in soil, manure, and runoff. Other P sorbing amendments (gypsum, flyash, and water treatment residuals) were included in the evaluation. Soil P reduction was evaluated by amending three different soils at five different rates, incubating for two weeks, and extracting with Mehlich-3 and water. Manure P reduction was evaluated by conducting an isotherm involving the addition of each material to dairy, swine, and poultry manure at six different rates using a manure:solution ratio of 1:200 and shaking for 16 h before filtration and P analysis. Runoff boxes containing Othello soil were amended at the rate of 20 g 100g-1 soil and subjected to simulated rainfall applied at the rate of 7.5 cm hr-1. Runoff was collected and analyzed for dissolved P, total P, and sediment concentrations. Results showed that calcium, iron and aluminum rich AMD residuals were at least equally effective in reducing soil and runoff P concentrations compared to other materials, while manure P reductions varied based upon manure and material properties.

Biography
Chad Penn received his B.S. in soil science from Penn State University in 1998, followed by a M.S. degree in environmental soil science from the University of Delaware (2001). His research at the University of Delaware involved studying the effects of wastewater treatment processes on the chemical properties of biosolids and the potential impact of those biosolids on water quality when land applied. While at Virginia Tech, he earned a Ph.D. in soil chemistry (2004) which involved research on predicting phosphorus concentrations in runoff based on soil properties, and the effect of soil mineralogy on phosphorus retention. He is currently working as a post-doctorate researcher at the USDA / ARS (agricultural research service) Pasture Systems and Watershed Management Research Unit, where his research involves determining the mechanisms of dissolved phosphorus losses in runoff, and reducing non-point losses of phosphorus to surface waters through the application of various industrial waste products.

Thursday 4:25 - Ron Neufeld

Accelerated Ferrous Oxidation with a Multiple Orifice Spray Reactor

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Abstract
This project focuses on an innovative active treatment technique for the management of acid mine drainage. Wet lands, lagoons and other passive systems are quite suitable for many abandoned mine applications or locations with large land space. However, numerous AMD discharges exist where active systems must be employed. Such sites include mine mouth applications, and underground mine pools from recently abandoned formerly active mine sites that are predicted to have "water blow outs" (and become new AMD discharges) in the next few years. In addition, some AMD sites are generators of potentially valuable quantities of relatively pure metals which can be reclaimed and marketed if managed suitably. A bench scale experiment using a multiple orifice spray reactor (MOSR) is investigated as a potential remediation technology for the rapid oxidation of ferrous iron from the St. Michaels (PA) acidic mine discharge. The MOSR makes use of flow through multiple orifices to enhance aqueous aeration and oxidation rates. The reactor consists of two concentric cylinders, the inner cylinder having a series of orifices which act in a manner similar to a venturi. In this fashion neutralization and aeration are combined into a single step due to the aspiration of air as a result of a pressure gradient across the reactor which allows for the introduction of an alkaline agent into a reaction chamber with detention time of seconds. Results show ferrous iron oxidation rates at pH values between 6 and 7 can be increased by four orders of magnitude as compared to theoretical oxidation rates. Under certain conditions the MOSR oxidizes more ferrous iron than can be simply attributed to the measured oxygen transfer capabilities of the system. It is suggested that the oxidation capability in excess of oxygen transfer is due to, or initiated by, the chemical effects of hydrodynamic cavitation. In addition, a relatively pure iron hydroxide product is rapidly generated from the St. Michaels AMD discharge which has reclamation potential. Field Applications of the MOSR: PPC Corporation has demonstrated the "Turbojett", a field scale prototype version of the OSR at several abandoned AMD sites at the 200 gpm to 400 gpm scale. Knowledge gained at the bench scale is being used by PPC to enhance future applications of multiple orifice type aerator-oxidizers.

Biography
Dr. Ronald D. Neufeld is Professor of Civil and Environmental Engineering at the University of Pittsburgh where he teaches and conducts research in the area of biological and physical/chemical processes for water and wastewater management. Dr. Neufeld holds a BE (Ch.E.) from Cooper Union; a MS (Ch.E.) from Northwestern University; and a Ph.D. in Civil/Environmental Engineering from Northwestern University. Dr. Neufeld is a registered engineer in Pennsylvania and holds Diplomate certification from the American Academy of Environmental Engineers. He has over 100 Journal publications and technical contributions to the environmental engineering literature.