The 24th Annual International Conference on
Soil, Water, Energy, and Air

presented by The Association for Environmental Health & Sciences Foundation

March 17-20, 2014
Mission Valley Marriott, San Diego, California

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BIOREMEDIATION

Electrochemical and Physical Mechanisms Affecting Optimal Subsurface Distribution of Electron Donor
Ed Alperin and Brad Elkins, EOS Remediation, Raleigh, NC; Robert Borden, Solutions IES, Raleigh, NC; Bahareh Karami, Black & Veatch, Charlotte, NC

Case Study: Full Scale Treatment of a Large Dilute TCE Plume using Bioremediation and MNA
Nathan Smith, Neil Smith, and Kent Sorenson, CDM Smith, Denver, CO; Sam Garcia and Mario Robles, US EPA Region 8, Denver, CO

Case Study: Applying Geochemical and Hydrogeological Data to Evaluate and Quantify Remediation by Natural Attenuation at a Petroleum Hydrocarbon-Impacted Site
Bradley Eisenberg, Stantec Consulting, San Diego, CA; Angus McGrath, Stantec Consulting, Lafayette, CA

Focused Bioremediation of Carbon Tetrachloride in Groundwater
Richard Evans, GES, Exton, PA; Jonathan Wadell, GES, Alpharetta, GA; Joseph Keller, GES, Odenton, MD
Electrochemical and Physical Mechanisms Affecting Optimal Subsurface Distribution of Electron Donor

Brad Elkins, Robert Borden, Bahareh Karami and Ed Alperin

The current convention is small droplet size of emulsified vegetable oil equates to remedial success through optimized distribution. To the contrary, this is not always true. Distribution is a function of lithology, hydrogeology and oil retention of the aquifer material. The use of emulsified vegetable oil as an electron donor for enhanced anaerobic bioremediation is well documented; however the electrochemical and physical mechanisms affecting distribution in the subsurface have not been extensively correlated to hydrogeological conditions or sediment facies.

Emulsion transport in the subsurface is governed by two mechanisms; 1) oil droplets have a negative charge creating an electrochemical attraction to positively charged clay materials and 2) colloid transport, observed as particle collisions with the matrix media. To demonstrate this phenomenon on subsurface distribution EOS Pro, a factory emulsified vegetable oil (60% oil, \(d_{50}= 1.0\) micron) and EOS 100, a water mixable vegetable oil concentrate for onsite dilution (85% oil, \(d_{50}= 7\) microns) were injected in porous media with various sediment types to explore oil retention as a function of droplet size.

The measured oil retention of EOS 100 was approximately one order of magnitude higher than EOS Pro in finer grained sediments. In coarse grain sediments the average oil retention for EOS Pro was half that of EOS 100. This clearly demonstrates larger oil droplet size increases oil retention. This property is important when designing remediation strategies for hydrogeological environments, such as high velocity aquifers or fractured bedrock where lower oil retention inadequately supplies electron donor.

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Presenting Author: Ed Alperin
Case Study: Full Scale Treatment of a Large Dilute TCE Plume using Bioremediation and MNA

Nathan Smith, Neil Smith, Kent Sorenson, Sam Garcia and Mario Robles

Managing dilute plumes to achieve remedial goals requires integrating source and plume treatment strategies. Active treatment of the core of the plume (specifically targeting the source area) is almost always required. Treatment of the lower concentration fringe can involve a combination of active remediation and MNA. Operable Unit 1 of the Bountiful Superfund site consists of a ½ mile-long TCE plume emanating from a residual source area. A full-scale remedial action is being implemented that features emulsified oil injections in the source area using a grid pattern of wells, and injections in the downgradient plume using three biobarriers.

The source area injection grid and the first biobarrier immediately downgradient of the source area were installed in 2008/2009. Results to date indicate that nearly the entire source area has been remediated, with only one monitoring well showing contaminants above treatment standards. Treatment of the downgradient fringe was initiated in 2011. Installation of these biobarriers incorporated the TRIAD approach to determine the lateral extent of injection well installation. A second amendment injection was completed in summer 2013. Results to date indicate that complete dechlorination to ethene is occurring, and measurable attenuation of contaminants has been observed downgradient of the biobarriers.

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Case Study: Applying Geochemical and Hydrogeological Data to Evaluate and Quantify Remediation by Natural Attenuation at a Petroleum Hydrocarbon-Impacted Site

Bradley Eisenberg and Angus Mcgrath

This case study shows how geochemical and hydrogeological data can be used to quantify the rate of remediation by natural attenuation (RNA) and evaluate its effectiveness at a site with petroleum-hydrocarbon impacted soil and groundwater. Biodegradation is generally the principle RNA mechanism of petroleum hydrocarbon degradation and most commonly occurs by aerobic and anaerobic respiration. Dissolved oxygen, nitrate, manganese, iron, sulphate and carbon dioxide/methane were evaluated to assess the role of each electron acceptor in the biodegradation of the petroleum hydrocarbons. In addition to aerobic respiration, anaerobic respiration processes included nitrate-reduction, manganese reduction, ferric iron-reduction, sulfate-reduction, and methanogenesis. Depth discrete samples were collected to evaluate the thickness of the plume and how plume thickness influences electron acceptor flux through the source area.

Comparison of the upgradient and downgradient electron acceptor concentrations provides evidence that RNA is occurring and a quantitative estimate of the rate of petroleum hydrocarbon biodegradation by aerobic and anaerobic processes. Contributions from each electron acceptor toward petroleum hydrocarbon biodegradation indicate that a combined benzene, toluene ethyl benzene and xylenes mass of 6,118 mg/L is biodegraded through processes that utilize all of the electron acceptors, with the greatest contribution coming from sulfate reduction and methanogenesis. Calculations followed ASTM E1943-98 (2010), which analyzes difference in electron donor concentration between up gradient wells and wells within the source area along a representative flow path.

The estimated annual mass of hydrocarbon as BTEX biodegraded by natural attenuation (assuming a cross sectional area of 220 ft. wide by 10 ft. thick and a Darcy flow rate or specific discharge of 0.00782 feet per day) is approximately 72 kg/year. These calculations can be used to estimate the contribution of natural attenuation to site remediation which can in turn be used to demonstrate that a low threat site has favorable conditions for closure based by RNA.

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Presenting Author: Bradley Eisenberg
Focused Bioremediation of Carbon Tetrachloride in Groundwater

Richard Evans, Jonathan Wadell and Joseph Keller

Background/Objectives. In 1998, a carbon tetrachloride source was identified in groundwater at a closed industrial landfill in the Shenandoah region of Virginia. This source was understood to be limited in horizontal and vertical extent. Historical attempts to further delineate this source yielded mixed results, but indicated that carbon tetrachloride impacts were localized.

Approach/Activities. To further delineate the carbon tetrachloride source; five (5) nested injection wells were installed in 2010 and 2011 in the source area, which was characterized by historical carbon tetrachloride concentrations up to 82.4 ug/L. Two (2) rounds of groundwater samples were collected from the injection wells to refine the volumetric distribution of the carbon tetrachloride impacts, which was subsequently determined to be localized within alluvial deposits which were overlying a shale layer.

Enhanced Bioremediation was conducted in the Spring of 2011 to target carbon tetrachloride impacts. Three (3) targeted injection wells were utilized. Biostimulation was conducted by the MaxOx Group® via co-injection of approximately 5,000 gallons of emulsified, long-term, vegetable-oil based electron donor (i.e., EOS Pro) along with a nitrogen gas injection technology. The nitrogen was applied to increase the radius of influence and distribution of the electron donor. Based on soil/groundwater acidity testing, a buffer was injected into the alluvial deposits to increase the pH to a value near physiological pH.

Results/Lessons Learned. Through subsequent performance monitoring, Enhanced Bioremediation has proven effective at reducing concentrations of carbon tetrachloride to either non-detect or below the US EPA MCL of 5 ug/L. As of October of 2012, reducing conditions are persistent in the treatment area, pH is within the optimal range between 6.0- and 8.0-standard units, and total organic carbon (TOC) and concentrations indicate that electron donor is still bioavailable. Increases in concentrations of intermediate products (i.e., chloroform and methylene chloride) were observed within the six (6) months following injection that indicated that the step-wise anaerobic reductive process was proceeding.

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EMERGING CONTAMINANTS

1,4-Dioxane Plume Conceptual Site Model Refinement and Remedial Design Optimization at a Former Manufacturing Site
Harry Van Den Berg, AECOM, Camarillo, CA; Rick Cramer, Eric Lang, and Gregory Yanagihara, AECOM, Orange, CA; Doug Roff, AECOM, San Diego, CA

The Removal of Antibiotics from Wastewater using the Advanced Oxidation Process (AOP) with Sulfate Radical
DeeAnn Asamoto, California State University, Long Beach, Torrance, CA

Recent Advances in Remediation Technologies for 1,2,3-Trichloropropane
Eric Suchomel, Geosyntec Consultants, Oakland, CA; Paul Tratnyek and Alexandra Salter-Blanc, Oregon Health and Science University, Portland, OR; Theresa Morley and Nancy E. Ruiz, Naval Facilities Engineering Command,
1,4-Dioxane Plume Conceptual Site Model Refinement and Remedial Design Optimization at a Former Manufacturing Site

Harry Van Den Berg, Rick Cramer, Doug Roff, Eric Lang and Gregory Yanagihara

Groundwater plumes of 1,4-dioxane, a cyclic ether used widely as a stabilizer for chlorinated solvents, tend to be extensive due to this compound’s high mobility in groundwater and its recalcitrance to biodegradation. 1,4-Dioxane plumes can therefore pose significant technical challenges and cost to contain and remediate, in particular when the Conceptual Site Model (CSM) is limited and selected remedy is not optimized.

AECOM recently designed, installed and started up a hydraulic containment/groundwater pump-and-treatment system to capture and treat groundwater contaminated with chlorinated volatile organic compounds (CVOCs) and 1,4-dioxane at a 28-acre former manufacturing facility. Recognizing limitations in the existing CSM for the site, the CSM was refined using Environmental Sequence Stratigraphy (ESS), a method that leverages existing stratigraphic information to understand the permeability architecture of aquifers. The refined CSM combined with updated groundwater flow modeling and particle tracking yielded a comprehensive basis for well field design to achieve hydraulic containment, and mass removal, as well as providing a framework for future data collection, planning, and process optimization.

This presentation discusses the results of the CSM refinement via ESS as well as actions incorporated in the remedial design to improve the efficacy, cost-effectiveness and sustainability of the selected remedy, including:

- Potential flushing of the vadose zone beneath the former release area to mobilize residual CVOCs and 1,4-dioxane for capture in the shallow aquifer thus removing future contributions from the source area and accelerating cleanup;
- “Steering” the plume via injection and extraction wells to accelerate plume remediation;
- Treatability studies and life-cycle cost analysis of advanced oxidation technologies capable of destroying hydrogen peroxide, including ultraviolet/peroxide and ozone/peroxide based systems
- A systematic review of green and sustainable technologies to identify those suitable for implementation during construction and system operation.

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The Removal of Antibiotics from Wastewater using the Advanced Oxidation Process (AOP) with Sulfate Radical

Deeann Asamoto

The deactivation of antibiotic activity in chemically-contaminated wastewater is necessary to minimize the proliferation of antibiotic resistant bacteria. One potential method of removal is the Advanced Oxidation Process (AOP) which is based in the production of highly oxidative radicals. In this study, the kinetics and reaction mechanisms for sulfate radical (SO₄⁻·) reaction with three classes of antibiotics were investigated. The rate constants determined for the reaction between SO₄⁻· and the tetracyclines, sulfonamides, and quinolones were fast, with average values of \((6.29 \pm 0.19) \times 10^9 \text{ M}^{-1}\text{s}^{-1}\), \((3.91 \pm 0.13) \times 10^9 \text{ M}^{-1}\text{s}^{-1}\), and \((6.83 \pm 0.16) \times 10^9 \text{ M}^{-1}\text{s}^{-1}\), respectively. The similarities in rate constants between SO₄⁻· and these three classes of antibiotics suggest that the sulfate radical oxidation is occurring at analogous sites located on each antibiotic molecule within each class. These data are necessary for the computer modeling of AOP use in real waters.

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Presenting Author: Deeann Asamoto
Recent Advances in Remediation Technologies for 1,2,3-Trichloropropane

Eric J. Suchomel, Paul Tratnyek, Alexandra Salter-Blanc, Theresa Morley, and Nancy E. Ruiz

1,2,3-trichloropropane (TCP) was used historically as a paint and varnish remover, a cleaning and degreasing agent, a cleaning and manufacturing solvent, and was a common component of soil fumigants previously used widely in agriculture. TCP is characteristically mobile in the subsurface and resistant to natural attenuation, and its persistence has resulted in impacts to more than 300 public water supply systems in California alone. Its toxicity to humans appears to be high relative to other chlorinated solvents, so even low-level exposures to TCP could pose significant human health risks. In 1999, the California Department of Public Health established a notification level for TCP of 0.005 micrograms per liter (µg/L) and in 2009 the California Office of Environmental Health Hazard Assessment (OEHHA) published a risk-based public health goal of 0.0007 µg/l.

Treating groundwater with low concentrations of TCP presents unique remedial challenges. Laboratory- and pilot-scale studies have been conducted over the past decade to investigate remedial options at several sites where groundwater is impacted by TCP and in some cases related agricultural chemicals. Numerous remedial technologies have been evaluated or implemented during these studies, including in situ bioremediation (ISB), a whole range of treatments used for in situ chemical reduction (ISCR), and in situ chemical oxidation (ISCO). This presentation will present the results of recent research and studies that have identified activated persulfate and zero valent zinc (ZVZ) are two particularly promising technologies for remediation of TCP.

A preliminary assessment of TCP treatability with activated persulfate was performed using heat-activation (70 °C) in deionized water in laboratory batch reactors. Approximately 85% of TCP initially present in the batch reactors was mineralized, indicating that persulfate has the potential for rapid and complete removal of TCP, if efficient activation can be achieved under field conditions. Follow up testing of groundwater from field sites impacted by TCP indicates that it is not degraded effectively by most strong oxidants including ozone, ozone/peroxide, and iron activated hydrogen peroxide. Additionally, persulfate and iron-activated persulfate did not induce significant degradation of TCP in our studies. However, alkaline-activated persulfate resulted in > 98% reduction in TCP in about seven days. The high pH (~12) control batch experiment resulted in degradation of approximately 80% TCP over the same time period, so base-catalyzed hydrolysis of TCP is likely to have contributed to the total observed TCP degradation by alkaline-activated persulfate.

Bench-scale batch and column tests have also been performed to evaluate types of ZVZ that might be suitable for remediation of TCP. Two industrial grade materials, Zn64 and Zn1210, exhibited good rates of TCP degradation in groundwater. A third material (Zn1239) was inhibited by the presence of oxygen in groundwater. Groundwater was observed to inhibit the reduction of TCP by zinc, but this affect was overcome in some instances by lowering pH. Based on the bench-scale results, Zn64 and Zn1210 were further evaluated in scaled-up, ex situ field columns. The field column results confirmed that ZVZ is a promising material for treating TCP, with TCP degradation of up to 95% maintained after 12 weeks of column operation. In addition, there were limited decreases in the rates of TCP degradation over time and no secondary impacts to water quality were identified. The results of the studies were used in the design of a pilot-scale ZVZ permeable reactive barrier that is planned for installation in spring 2012.

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Presenting Author: Eric Suchomel
ENERGY

Energy and the Environment-Relating Releases to Sources with Environmental Forensics
R. Paul Philp, University of Oklahoma, Norman, OK

Water and Energy: A Multi-Dimensional Resource Management Challenge
Eric Suchomel and Michael Kavanaugh, Geosyntec Consultants, Inc., Oakland, CA

Hydraulic Fracturing and the Impacts to Groundwater and Water Quality: The Importance of a Monitoring Program
Mark Zeko and Emily Vavricka, Environmental Engineering & Contracting, Inc., Santa Ana, CA

Effective Bacterial Enrichments in Marine Sediment Microbial Fuel Cells
Y. Meriah Arias-Thode, Lewis Hsu, and Anna Obraztsova, Spawar Systems Center Pacific (SSCPAC), San Diego, CA; Jessica Bloom, UC Berkeley, SSCPAC, Berkeley, CA

Application of Different Bio-catalysts for Bio-diesel Production from Waste Cooking Oil as Sustainable and Green Energy Process
Nour El-Gendy and Amal Hamdy, Egyptian Petroleum Research Institute, Cairo, Egypt

Who Owns The Arctic? The Implication of National Policy Decisions That Will Drive Economic and Environmental Issues over the Next 20 Years
Kyle Parker, Crowell & Moring LLP, Anchorage, AK
Energy and the Environment-Relating Releases to Sources with Environmental Forensics

R. Paul Philp

With the ever increasing demand for all forms of energy both in this country and world wide, it is inevitable that there will be more and more releases of energy products into the environment. These releases may be oil or gas—even coal—or products related to exploration and production activities. In terms of exploration there are many issues associated with hydraulic fracturing which will be discussed elsewhere at this meeting. This will inevitably lead to increasing levels of litigation requiring more and more sophisticated techniques to relate releases to their point of origin. These releases may be accidental and unintentional or in some cases even deliberate. Further complicating the issue is the fact that in many areas releases may occur in the same area as natural seeps or areas with significant tanker traffic that also contribute to the overall contamination background. Every release will have its own specific set of characteristics. These will depend on such features as the nature of the product and environmental conditions where the release occurred.

In this presentation the primary focus will be on issues related to oil spills and various refined products derived from crude oils. It is proposed to discuss both traditional and emerging techniques that can be used to both relate the spilled oil to its source and at the same time differentiate the spilled oil from seeps and other sources of oil in the area. Much of the data used in this process is closely related to that used in oil exploration and interpretation of these results can greatly benefit from such knowledge. This is also particularly important since oils start to undergo alteration as soon as they are released into the environment and a detailed understanding of changes resulting from these weathering processes is an important part of the interpretation.

In summary this talk will review and discuss forensic approaches to monitoring oil spills and how the data are used to relate the spilled oil to its source. Similar approaches to monitoring refined products will also be discussed.

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Presenting Author: R. Paul Philp
Water and Energy: A Multi-Dimensional Resource Management Challenge

Eric J. Suchomel and Michael Kavanaugh

Water and energy are intertwined resources, with water used in the production of energy, and energy used in the generation and transport of fresh water. Power production in the United States has been estimated to consume 3% of the nation’s water annual, and 13% of the energy produced in the United States each year is used to treat, transport, and heat fresh water. The phrase “water-energy nexus” has been coined to describe the interrelation between these resources and focus attention on the role of reliable, abundant, and predictable sources of water on future energy security for the United States.

One important set of issues at the water-energy nexus is the ongoing management of water sources and the potential impacts to water quality related to energy production. This presentation will present a discussion of the water-energy nexus, focused on selected issues related to water quality and management arising from and related to energy production. Specific issues discussed will include:

- Water quantity demands related to the exploration, extraction, and generation of energy and energy sources;
- Energy demands related to water management, including extraction, transport, treatment, and disposal of water;
- Water production during hydrocarbon extraction; and
- Potential impacts to water quality that may arise from the production of energy from “unconventional” sources of oil and gas.

The presentation will conclude with a discussion of research needs and opportunities to improve our understanding of the water-energy nexus and to move towards development of more sustainable production of energy and water.

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Presenting Author: Eric J. Suchomel
Hydraulic Fracturing and the Impacts to Groundwater and Water Quality: The Importance of a Monitoring Program

Mark Zeko and Emily Vavricka

Hydraulic fracturing has been used to stimulate production of oil and gas since the late 1940’s throughout the U.S., including California. In the late 1980’s to early 1990’s advances in horizontal drilling processes and fracturing techniques resulted in a significant increase in this enhanced production technique. Fracking techniques typically involve the injection of large quantities of water and proppant. The fracturing fluid chemistry is often complex, consisting of hundreds of chemicals designed to serve a variety of purposes, including corrosion and scale inhibitors, biocides, thickening agents, friction reducers, pH adjustment, and borehole and well cleaning. These chemicals can include diesel fuel, BTEX, 1,4 dioxane, ethylene glycol, hydrochloric and hydrofluoric acids, and naphthalene. Groundwater can potentially be impacted from a number of different processes including faulty well construction, improperly abandoned wells, fault zones, releases from surface impoundments, leaks and spills, stormwater runoff, chemical storage, and underground injection of flowback water.

Because of the large variety of chemicals potentially contained in the fracking fluid and flowback water, a comprehensive groundwater and surface water sampling and monitoring program should be designed and implemented. Included with this program should be a comprehensive baseline analysis of existing conditions to document any deleterious conditions that may exist prior to development. In California, Senate Bill No. 4 was recently passed and went into effect January 1, 2014. This bill mandates groundwater monitoring in the vicinity of wells subject to hydraulic fracturing or other forms of formation stimulation.

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Presenting Author: Mark Zeko
Effective Bacterial Enrichments in Marine Sediment Microbial Fuel Cells

Y. Meriah Arias-Thode, Anna Obraztsova, Jessica Bloom and Lewis Hsu

The Navy has a need for persistent energy production in marine sediments. This need is ideally met by marine sediment microbial fuel cells (SMFCs); however several technical hurdles face their adoption as a viable energy source. Reliability, stability, and start-up operational time are key aspects of SMFCs that should be improved. Due to the heterogeneity of the microbial community; power production can be delayed by approximately one month or can be unreliable. To overcome some of these barriers, we explored enriching for an established microbial community capable of meeting these requirements.

Two SMFC units were operated using marine sediments collected from San Diego Bay and placed in mesocosms in flow-through systems. Voltage of the units was regulated to achieve maximum power production in each unit. Initially, these units took one month to reach maximum power. After certain time points, the established biofilm community on the electrodes were transferred to new mesocosms systems. After several transfers, the period of time for maximum power production was decreased to 2 days versus one month; and the power production was increased by a factor of two; from 10mW/m$^2$ to 20mW/m$^2$.

Microbiological and molecular biology analysis were performed in parallel to the transfers to understand the key players involved in energy production. Initial results indicate elevated numbers of sulfate-reducing bacteria associated with the anode versus control. Iron-reducing bacteria (FeRB) and fermenting bacteria were also evaluated for their contribution to power production in the SMFC. However, initial culturing data does not show significant differences in numbers of FeRB and fermenting bacteria versus control. Denaturing gradient gel electrophoresis will be used to evaluate the microbial community in the SMFC systems. These systems may offer the Navy a unique form of persistent renewable energy that can be used to power sensors, communication devices, and vehicles to support the Navy needs in these areas.

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Application of Different Bio-Catalysts for Bio-Diesel Production from Waste Cooking Oil as Sustainable and Green Energy Process

Nour El-Gendy and Amal Hamdy

In Egypt, solid municipal wastes density averages 300 kg/m³. The organic materials constitute up to 60% of these wastes. The annual consumption of vegetable oil in Egypt exceeds million MT/year. Consequently, millions of liters of waste cooking oil WCO are annually discarded. All of these add to the cost of waste management and cause a lot of environmental and economic problems. The depletion of conventional petro-diesel with its accelerating and frequently fluctuating price, together with growing environmental concerns have led to the steadily gaining attention for bio-diesel production.

In this study, some domestic wastes; animal bones, eggshells and mollusks shells were used to produce heterogeneous bio-catalysts by simple calcination process. The physico-chemical characteristics of the prepared bio-catalysts were done by thermo-gravimetric analysis TGA/DSC, X-ray diffraction XRD, laser raman spectroscopy, scanning electron microscopy SEM and Fourier transform infrared FTIR spectroscopy. A comparative study for bio-diesel production from WCO using the produced bio-catalysts, standard Novozym 435 and laboratory chemical calcium oxide CaO was carried out. All the prepared bio-catalysts show high bio-diesel production activity (> 90% fatty acid methyl esters FAME in 1 h). The produced bio-diesel shows a high quality product with good and acceptable fuel properties compared with those of Egyptian petro-diesel standards and ASTM D6751 and EN 14214 standards of bio-diesel.

The production of bio-diesel from WCO using heterogeneous bio-catalysts produced from domestic wastes offers a triple positive impact solution to economic, environmental and energy problems.

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Presenting Author: Nour El-Gendy
Who Owns The Arctic? The Implication of National Policy Decisions That Will Drive Economic and Environmental Issues over the Next 20 Years

Kyle Parker

Once a forbidding frontier of the Cold War, the Arctic has become the theatre for dramatic environmental, economic and political change. Media reports trumpet the opening of new Arctic sea routes and a “rush” to resource riches. Less well understood are the powerful political events that have shifted power northwards over the past forty years through indigenous land settlements in North America, and the devolution of power over lands and resources to Alaska, Canada’s Northern territories, Greenland and Arctic Norway.

In this presentation, we will discuss the most recent US Geologic Survey estimates of the hydrocarbon resources anticipated in the Arctic, both on and offshore. We will also discuss the national security implications of new development in the Arctic, the strategic importance of the various shipping routes that are opening once again, and the lack of critical infrastructure to support that development.

The United Nations Law of the Sea Treaty lays out a path for the Arctic nations to assert their sovereign rights in regard to the Arctic. The United States has not ratified the Treaty; we will discuss the implications of not doing so both from an economic and environmental standpoint. The competition for the Arctic is fierce and the United States is not in the game. In addition, the border between Canada and the United States is disputed offshore in the Beaufort Sea. We will discuss the positions of the two countries and the most recent discussions between the State Department and Canada's Foreign Affairs Ministry. We will also discuss the evolving role of the Arctic Council and the ongoing dialogue concerning governance of the Arctic.

Lastly, we will discuss the regulatory uncertainty and operational challenges facing companies looking to expand operations into the Arctic, including:

- the unsuitable application of "one size fits all" regulatory standards from the Lower 48 to Alaska
- the lack of clear criteria and regulatory framework related to exploration and development activities in the Arctic, specifically in regard to developing spill contingency plans, securing air quality permits, incidental take authorizations, etc.
- preservation of the subsistence lifestyle and tribal and municipal government concerns
- MMPA/ESA/Migratory Bird Act issues arising as vast areas are deemed critical habitat for marine mammals and migratory birds
- timing restrictions to accommodate whaling and ice conditions which are being exacerbated by climate change
- the lack of infrastructure to support activities as well as the environmental issues which surround further development and expansion of infrastructure
- considerable ENGO opposition to all Arctic development activities.

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ENVIRONMENTAL FORENSICS

How to Interpret Your 3D-CSIA Forensic Data Report: A Step-By-Step Demonstration
Yi Wang, PACE-ZymaX Forensics Isotope, Escondido, CA

Contaminant Source Identification using Laboratory Chemical Data Derived from Remedial Site Investigations
Jun Lu, AECOM, Long Beach, CA

Robust Data Analysis for Utilizing Chemical Data for Forensic Applications
Adam Love, Roux Associates, Inc., San Francisco, CA; Christopher Brown, Decision Patterns, Oakland, CA

Forensic Identification of Asbestos Source Strength from Braking Systems of On-the-Road Vehicles Using Polarized Light and Transmission Electron Microscopy
Stephen Wall, Jeff Wagner, and Diamon Pon, California Department of Public Health, Richmond, CA

Forensic Analysis of PCB Origins in a US Gulf Coast Bay

Cutting-Edge Techniques in Environmental Forensics
Ioana Petrisor, San Diego, CA
How to Interpret Your 3D-CSIA Forensic Data Report: A Step-By-Step Demonstration

Yi Wang

Three-Dimensional Compound Specific Isotope Analysis (3D-CSIA) has been demonstrated to be a promising approach for chlorinated solvent release site investigation. Obtaining carbon, chlorine, and hydrogen isotopic signatures of PCE, TCE, and their daughter products in groundwater, soil, and vapor samples helps distinguish multiple release sources and assess biodegradation.

How to interpret a 3D-CSIA forensic data report has been a big challenge to many site managers, however. It requires a full understanding of isotope geochemistry, stable isotope forensic approach, and science-defendable interpretation based on the site information. For example, the typically negative isotope ratios obtained by 3D-CSIA for the target analytes are different from the positive concentrations obtained by the traditional EPA method 8260B for the same analytes. Further, altered isotope ratios due to certain weathering effects like in situ degradation, if occurring to the target analytes, would give data interpreters a lot of trouble, esp. when they want to apply such data for contaminant source identification.

During this presentation, a complicated PCE/TCE release site case study is used to step-by-step demonstrate how we interpreted one of our 3D-CSIA data reports. Concentrations and carbon, chlorine, and hydrogen isotope ratios of PCE, TCE, and cDCE were measured in 31 shallow and deep groundwater samples from the site. In these samples, at least 8 PCE sources and 1 TCE source were distinguished based on the isotopic signatures and the locations of the samples. Potential contaminant sources could be from a variety of historic industrial activities at the site.

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Presenting Author: Yi Wang
Laboratory chemical analyses are probably the most important data for remedial site investigations. The analytical results reported by the laboratory are typically presented as a concentration. Primary uses of the results include: 1) comparison to regulatory guidance to determine if the concentration exceeds guidance values; 2) delineation of extent of contaminants in soil, soil gas and/or groundwater. The analytes are primarily chemicals of potential concern, but substantial amount of forensic information may be derived from these laboratory analyses and used to identify potential contaminant source(s).

This presentation provides a systematic approach to evaluate laboratory chemical concentration data from a forensic perspective. The concentration data are either used alone or combined with other aquifer soil gas and/or soil matrix parameters to reveal the information that is of value in contaminant source identification. The methods include: 1) spatial patterns of contaminant at the site; 2) temporal trends of a contaminant at a monitoring well; 3) chemical diagnostic ratios; 4) inter-chemical correlations; 5) phase equilibrium and 6) contaminant mass flux and discharge. In addition, data beyond standard laboratory reports involving gas chromatography/flame ionization detector and gas chromatography/mass spectrometry analyses are discussed and additional “non-reported” data and raw data are mined to bridge the data gaps.

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Robust Data Analysis for Utilizing Chemical Data for Forensic Applications

Adam Love and Christopher Brown

Analytical chemistry data for forensic applications can be generated faster and with more detail and fidelity than ever before. Developing a robust methodology to analyze the chemical data is often a secondary consideration to the data collection itself. What generally results is generic analyses that overlook optimization of data collection as well as the full utility of the data being collected.

Chemical forensic typically involves comparison of individual samples or groups of samples to other samples or groups. Such comparisons are used for matching or classification purposes that provide some of the basis for making confident forensic conclusions regarding elements such as origin, manufacturing, and/or timing. While it may appear that comparison analyses can be performed “by eye”, there are numerous pitfalls to not implementing a thorough statistical analysis to align the data and analysis objectives.

Strategies for development of a classification system for chemical data where reference samples do not exist provide even greater challenges and are often inhibited by the “cold start dilemma”. A systematic methodology for building a classification system must advance through a logical framework that builds a model system and then assesses and validates the model through the implementation of independent chemical datasets.

This presentation describes important considerations for the analysis of chemical data for forensic applications, optimization strategies and pitfalls for forensic matching and grouping, and considerations for how multiple lines of evidence can be appropriately melded into a “data fusion” outcome. Key points will be reinforced through case study examples from a range of fields that utilize chemical forensics.

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Presenting Author: Adam Love
Forensic Identification of Asbestos Source Strength from Braking Systems of On-the-Road Vehicles Using Polarized Light and Transmission Electron Microscopy

Stephen Wall, Jeff Wagner and Diamon Pon

The US EPA instituted a ban on most products containing asbestos in 1989; however, automotive dry friction materials (ADFM) including drum brake linings were subsequently exempted from the ban in 1991. However, there is insufficient knowledge concerning motor vehicle asbestos brake dust emission rates and brake friction material inventories of asbestos, a known carcinogen. Assessment of the potential health effect consequences from asbestos brake friction materials (BFM) requires the identification of the asbestos fiber type and classification of fiber size, as well as, the determination of the asbestos concentration in brake dust emissions.

Based on knowledge of the California registered vehicle population and those drum brake vehicles likely to have asbestos containing BFM, a vehicle target list was used to collect used brake shoes for asbestos analysis by polarized light microscopy (PLM). PLM analysis of used asbestos BFM collected from target vehicles currently in operation, determined chrysotile asbestos to be the primary constituent by mass, consistent with the manufacturer's specifications. Sampling of the brake dust emissions from rear drum brakes of a vehicle operated on a chassis dynamometer was conducted over both California and Federal standard driving cycles, designed to model typical vehicle acceleration and braking patterns.

From the transmission electron microscopy (TEM) analysis, entrained dust collected on braking system surfaces contained chrysotile fibers < 10 um length. Most fibers counted were < 1 um length; however, sufficient longer fibers were present for the mass distribution to extend to much longer fiber lengths. The number distribution of airborne fiber length and mass were similar to those for the entrained brake dust collected from the brake system surfaces, with some variation due to driving cycle type and duration. TEM selected area electron diffraction (SAED) demonstrated that most asbestos was denatured during braking; however, near source exposures can exceed the Federal AHERA standard.

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Presenting Author: Stephen Wall
Forensic Analysis of PCB Origins in a US Gulf Coast Bay

Juliana Atmadja, Edward A. Garvey and Xiulan Wang

PCBs remain a problem in many estuaries around the US. In this gulf coast bay and its associated river, PCB levels in fish remain elevated despite the passage of time, resulting in state fish consumption advisories for all sports fish. PCB levels in sediments of the river and bay are relatively low with typical values less than 20 ug/kg. Despite the low absolute levels, the forensic analysis was able to discern the existence of at least 2 PCB sources, a minor one originating in the upper reaches of the river, and a second, larger one originating roughly 10 km upstream of the river’s confluence with the bay, coincident with a chemical plant along the river. In this study, we utilized a statistical tool called principal component analysis, along with other lines of evidence to understand the spatial distribution of PCB concentrations and patterns throughout the river and bay and formulate our conceptual site model. Based on the linear portion of the system (the river) we were also able to estimate the relative magnitude of the 2 sources. Our examination showed that there is a statistically significant increase in PCB concentration and TOC-normalized PCB concentration downstream of Km point 10 (KP 10), coincident with the plant site location. Accompanying this increase in PCB concentration is a change in the PCB pattern to lower molecular weight PCBs, such that all locations with elevated PCB concentrations below KP 10 are characterized by the pattern originating at KP 10. We were able to make use of PCB pattern, PCB concentration and the level of PCB-11 in identifying the existence of a major downstream source downstream of KP 10. The PCB fingerprint in the sediments in much of the bay retains the pattern originating from the river below KP 10.

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Presenting Author: Juliana Atmadja
Cutting-Edge Techniques in Environmental Forensics

Ioana Petrisor

Environmental forensics is a well-established and growing scientific field that uses a large variety of fingerprinting techniques in order to reconstruct environmental contamination history. This presentation will provide an overview of the state-of-the-art in fingerprinting, emphasizing on cutting-edge emerging techniques such as chiral fingerprinting, position specific isotopic analysis (PSIA) and mineralogical fingerprinting through the inter-dependent use of microscopy and chemical analyses. Relevant case studies related to petroleum, PCBs, MTBE and metal contamination will be overviewed in order to illustrate the practical applications of each of the cutting-edge techniques, resulting in ultimate solutions to complex environmental puzzles.

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ENVIRONMENTAL IMPACT OF NANOTECHNOLOGY

Risk Management of Emerging Nanotechnologies
Lawrence Gibbs, Stanford University, Stanford, CA

Environmental Implications of Nanotechnology
Hilary Godwin, UCLA Fielding School of Public Health, Los Angeles, CA

Nanomaterials Human Exposure Toxicology
Kent Pinkerton and Amy K. Madl, University of California, Davis, CA

Nanoregulatory Policy Past, Present, and Future
Timothy Malloy, UCLA School of Law, Los Angeles, CA
Risk Management of Emerging Nanotechnologies

Lawrence M. Gibbs

Nanotechnology is being heralded as a driver of the next technological and economic wave, and business enterprise development in this emerging field holds much promise. Applications utilizing nanomaterials are increasingly prevalent in the many commercial arenas.

An understanding of issues involved with the application of nanomaterials and nanotechnology is important to gain an appreciation of the issues related to risk management of this emerging technology. The properties of nanoparticles (e.g., size, surface area, reactivity) that yield many of the far-reaching societal benefits may also pose risks. The challenge is to determine whether the nature of engineered nanostructure materials and devices present new safety and health risks. At the same time, there is a need to address how the benefits of nanotechnology can be realized while proactively minimizing the risk. Growing concern over the potential and perceived risks of nanomaterials is leading to regulatory action that will impact organizations conducting research or developing new applications in the nanomaterials area.

This presentation will provide an introduction to and overview of the emerging field of nanotechnology, and review the health, safety, environmental concerns, and emerging regulatory and related issues involved with nanomaterials. The focus will be on identifying what is known, and unknown, about possible risks, review of exposure assessment techniques for small particles, and discussion of how to address knowledge gaps.

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Presenting Author: Lawrence Gibbs
Environmental Implications of Nanotechnology

Hilary Godwin

The United States has invested over $18 billion on research in and development of nanotechnology since FY2001 with the goal of stimulating our economy and improving our standard of living. This investment centers on the premise that nanomaterials, by virtue of their novel properties, have the potential to revolutionize many commercial products and processes, including electronics, therapeutics and medical diagnostics, and high performance materials. Nanotechnology also has the potential to fuel a “green revolution” in American industry, by enabling the development of better fuel cells, batteries, and solar panels, as well as systems that can detect and clean up pollutants in the environment.

However, some of the attributes of nanomaterials, such as the novel biological properties that make them so useful for medical applications, also confer hazards that are not found in analogous bulk or micron-sized materials. In addition, because of their small size, the fate and transport of nanomaterials in the environment often differs from bulk analogs. As a result, assessing the risks of nanomaterials and nano-enabled products to both people and the environment presents a number of new challenges.

To tackle these challenges, the National Science Foundation and the Environmental Protection Agency have funded the University of California Center for Environmental Implications of Nanotechnology (UC CEIN). This presentation will provide an overview of the wide-ranging interdisciplinary work being performed in the UC CEIN. The presentation will include an overview of some of the new methodologies that have been developed in the center as well as critical insights that have been gained about how we can use “safer by design” approaches to develop nanomaterials that have the necessary materials properties for their intended applications but present less risk to people and the environment.

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Human exposure toxicology for a number of products must include 1) hazard identification, 2) dose-response assessment and 3) exposure assessment to determine risk characterization. Engineered nanomaterials clearly fall into a category of urgent need for hazard assessment as we continue to investigate these materials for their incredible potential in advances for medicine, energy/fuel conservation, electronics, and environmental remediation. The fact that nanosized particles 1) have a potentially high efficiency for deposition; 2) target both the upper and lower regions of the respiratory tract; 3) are retained in the lungs for a long period of time, and 4) induce more oxidative stress and cause greater inflammatory effects than their fine-sized equivalents suggest a need to study the impact of these particles on the body. Achieving a better understanding of the dynamics at play between particle physicochemistry, transport patterns, and cellular responses in the lungs and other organs will provide a future basis for establishing predictive measures of toxicity or biocompatibility and a framework for assessing potential human health risks.

Questions facing researchers, regulators, industry, and insurers are how nanomaterials can be developed and used to maximally benefit our society, but minimally impact human and environmental health. Although nanotechnology is a relatively new field, our historical experience with other well-studied ultrafine particles can provide insight as to how engineered nanoparticles may behave in the body. There are many factors that are likely to influence the aerosolization and potential inhalation exposure of nanoparticles, many of which are also likely to impact the physicochemical characteristics of the airborne nanoparticles, in turn affecting the biological fate and response. Identifying the exposure or dose metrics that correlate to the most sensitive health effects will be important for conducting risk assessments and establishing standards for protecting human health.

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Presenting Author: Kent Pinkerton
Nanoregulatory Policy Past, Present, and Future

Timothy F. Malloy

The unique nature of nanomaterials and the governance challenges they present are by now well known. Regulatory science and policy have responded, generating a suite of emerging and re-purposed policy approaches and evolving methodological advances. In the regulatory arena EPA and FDA have actively engaged in regulation of nanomaterials in a range of existing programs. While OSHA has been slower to take action, NIOSH has been quite active with respect to risk assessment and risk management. At the state level, active regulation of nanomaterials is very limited, with California being the most active. Emerging approaches to predictive toxicology and environmental impact assessment have progressed significantly over the last decade, offering a way forward for further conventional regulation and the possibility of fundamental changes in our regulatory frameworks. This presentation provides an overview of the existing regulatory environment and a roadmap to potential regulatory change, including adaptation in conventional programs and the emergence of new regulatory approaches.

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Presenting Author: Timothy Malloy
HYDRAULIC FRACTURING REGULATORY AND TECHNICAL UPDATE

Well Stimulation Treatment Regulations in California – A Look to the Future
Vincent Agusiegbe, California Division of Oil, Gas and Geothermal Resources, Sacramento, CA

Current Legal Issues Concerning Hydraulic Fracturing
Charles Correll, King & Spalding, San Francisco, CA

Hydraulic Fracturing: Developing Water and Oil & Gas Sector Partnerships
John Whitler, Water Research Foundation, Denver, CO

Gas Well to Water Well Subsurface Contaminant Pathways – Plan for Investigation
Rickard Railsback, CURA Environmental & Emergency Services, Plano, TX

Practical Guidelines for Evaluation of Baseline Groundwater Quality and Potential Impacts in Areas of Active Shale Gas Extraction
John Connor and Lisa Molofsky, GSI Environmental, Inc., Houston, TX; Stephen D. Richardson, GSI Environmental, Inc., Austin, TX; Anthony Daus, GSI Environmental, Inc., Newport Beach, CA
Well Stimulation Treatment Regulations in California – A Look to the Future

Vincent C. Agusiegbe

Although the concepts and application of well stimulation treatment techniques have been around for many years, the understanding of how and why they are used are less understood. The Division of Oil, Gas, and Geothermal Resources (Division) is the regulatory agency responsible for supervising the drilling, reworking, abandonment, and operations of oil and gas activity to prevent possible damage to life, health, property, and natural resources. The Division has and will continue to set strict construction standards for the oil and gas wells, employing zonal isolation methods, which is one safety aspect relative to well stimulation treatment techniques. The Division is actively working on permanent well stimulation treatment regulations to address additional concerns and to ensure that air, water and the hydrocarbon resources are protected. If the relationship among the well stimulation treatment control variables is properly understood, early control and regulatory measures could be adopted in dealing with the environmental concerns raised by the well stimulation treatment operations.

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Presenting Author: Vincent C. Agusiegbe
California’s Monterey Shale holds an estimated 13.7 billion barrels of oil that could potentially be recovered through the use of hydraulic fracturing. This is roughly two thirds of the nation’s total predicted shale oil reserves according to some reports. Yet hydraulic fracturing remains controversial, especially in California. Senate Bill 4 now requires California’s Division of Oil, Gas, & Geothermal Resources (DOGGR) to enact new regulations governing fracking and also to conduct a statewide Environmental Impact Report. DOGGR’s proposed regulations have been issued. Additionally, environmental groups have sued for a more stringent environmental review under the California Environmental Quality Act (CEQA). The presentation will provide updates on all these fronts, discuss potential litigation that the proposed regulations may spawn, and evaluate pro-active measures to both comply with the regulations and address potential lawsuits.

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Presenting Author: Charles C. Correll
Hydraulic Fracturing: Developing Water and Oil & Gas Sector Partnerships

John Whitler

In an effort to build on its previous work on hydraulic fracturing, WRF will be sponsoring a workshop at the end of April to support water utility efforts to improve their relationship with oil and gas companies. This workshop will cover key topic areas such as monitoring, emergency response, and operations to help water utilities and oil and gas companies:

- Improve response to emergency situations such as spills
- Understand how and what to monitor for
- Share water system management strategies at hydraulic fracturing operations
- Share the latest research results

Water utilities are increasingly interested in oil and gas production activities that are occurring in their service areas and watersheds. Often times these operations are regulated under different agencies than water utilities, which can create coordination challenges. Many utilities recognize that these operations are already occurring or will be shortly in their area. These utilities are not focused on debating the safety of these activities, but are concerned about the potential impacts these operations will have on their utility. Several key topics have been identified by utilities including monitoring, emergency response, and operations. Many utilities face challenges in coordinating with these oil and gas companies and would like to develop better information exchange and partnerships. This workshop will help accomplish this while also helping to identify future research projects that need to be conducted.

During my talk at the AEHS conference, I will present some preliminary findings from pre-workshop efforts. I will also provide an overview of other current research activities that WRF is involved in related to hydraulic fracturing.

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Presenting Author: John Whitler
Gas Well to Water Well Subsurface Contaminant Pathways – Plan for Investigation

Rickard Railsback

With the advent of horizontal drilling and frac technologies which allow the commercial production of oil and gas from very low permeability rocks, onshore North America is undergoing a historic drilling boom. The industry is now drilling in areas never drilled before – densely populated and often with significant, beneficial use aquifers in the shallow subsurface. Is oil and gas drilling, fracing, and production endangering the nation’s groundwater supplies? Are water wells and aquifers being contaminated with oil and gas, drilling mud, and/or frac fluids? Numerous tools and methods of investigation can be used to answer these questions: proximity; timing of the impact; other contaminant sources; oil and gas well records; pressure data from the gas well and water well; data on frac geometry; natural gas, condensate, and water composition; seismic data; cement bond logs; noise logs; temperature logs; gamma ray logs; radioactive tracers; pressure interference tests; and installation of monitoring wells. Effective use of these tools will solve the problem of whether or not an oil or gas well has contaminated a water well. Operators can utilize these tools to educate the public and landowners, promote and defend drilling programs, and in litigation support.

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Evaluation of water quality data from hundreds of pre-drill water well samples in Susquehanna County, Pennsylvania, shows natural methane concentrations in groundwater to be strongly related to three independent factors: the topographic location of the water well, the ionic composition of the groundwater, and the redox state of the groundwater. Specifically, higher background methane concentrations are observed in valley vs. upland wells, and in sodium and chloride-rich waters vs. calcium-bicarbonate waters. Our further analysis of relevant geochemical data shows that an additional driver in the spatial and temporal variability of natural methane concentrations is the redox state of the groundwater. These geochemical factors are important considerations for design, implementation, and interpretation of baseline monitoring programs for shale gas development projects, including the selection of appropriate monitoring parameters, characterization of the expected range of natural variability, and evaluation of natural vs. induced changes in water quality after drilling and development operations.
INNOVATIVE REMEDIAL TECHNOLOGIES

Rapid Remediation of Hexavalent Chromium in the Vadose and Saturated Zones Using In-Situ Chemical Reduction
Jeremy Squire and Paris Hajali, Murex Environmental, Inc., Irvine, CA

Case Studies on the use of PersulfOx® Catalyzed Persulfate ISCO Technology
Danny Nunez and Bryan Vigue, Regenesis, San Clemente, CA

Alternative Air Sparge Test Method using SF6
Jason Phillips, Antea Group, Otsego, MI; Chris Michalek and Megan Royal, Antea Group, Novi, MI

Model for Compound Specific Isotope Analysis (CSIA) of Chloroethene Results to Produce Data Interpretable with First-Order, Rayleigh Kinetics
Patrick McLoughlin and Robert Pirkle, Microseeps, A Division of Pace Analytical, Pittsburgh, PA; Aaron Peacock, Haley and Aldrich, Oak Ridge, TN; John Wilson, US EPA, Ada, OK; Richard McCracken, Shaw Environmental & Infrastructure, Monroeville, PA

Combined Remedies for Rapid Remediation of Chlorinated Solvents - Synergies, Results, and Lessons Learned
Christopher Gale, Brian Hitchens, and Sam Williams, Geosyntec Consultants, San Diego, CA; Doug Riddle, RE LLC, Mountain Center, CA

Magnetic Susceptibility to Verify Zero-Valent Iron (ZVI) Distribution in Subsurface Soil
Nathan Diem and Tina Pham, Conestoga-Rovers & Associates, Emeryville, CA; Vibhav Mankad, Conestoga-Rovers & Associates, Concord, CA
Rapid Remediation of Hexavalent Chromium in the Vadose and Saturated Zones Using In-Situ Chemical Reduction

Jeremy Squire and Paris Hajali

A legacy of manufacturing operations in the United States and abroad has resulted in vast stores of groundwater resources being impacted by the toxic forms of chromium, which are the compounds that contain the element in its +6 oxidation state. Los Angeles' San Fernando Valley Basin, an important source of drinking water for the Los Angeles metropolitan area, has been designated a Superfund Site.

Although the California MCL for total chromium is 50 ug/L, the California Office of Environmental Health Hazard Assessment released a Final PHG (the precursor to an MCL) at 0.02 ug/L in July 2011. This development has underscored the need to develop more advanced approaches to achieve remediation goals at sites where soil and groundwater are impacted with Cr+6 and is driving the environmental industry towards higher cost investments in Cr+6 cleanup.

This presentation discusses the controlling and limiting mechanisms for reduction/stabilization treatment and lays out lessons-learned for applying reduction/stabilization treatment using field and bench scale data generated from an active aerospace production facility in the Los Angeles area (Site).

At the Study site, concentrations of Cr+6 exceeded 5,000 ug/kg in vadose zone soil and 5,000 ug/L in groundwater, below a depth of 70 feet. Injection of a reducing agent, calcium polysulfide (CPS), in both the vadose zone and saturated zone, resulted in significant reduction of Cr+6 concentrations to levels below approved cleanup goals. The reduction reactions were complete within only weeks, and were demonstrated through the collection of confirmation soil and groundwater samples.

The lessons learned in this exercise include a cost/benefit analysis of CPS dosing, ways to overcome field challenges, such as the formation of precipitation in injection tooling, estimates for timing confirmation sampling, the limitations of treatment short- versus long-term, and laboratory QC challenges, such as matrix interference.

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Presenting Author: Jeremy Squire
Case Studies on the use of PersulfOx® Catalyzed Persulfate ISCO Technology

Danny Nunez and Bryan Vigue

Traditionally in situ chemical oxidation using sodium persulfate has been widely used as a mass removal reagent for the treatment of a range of soil and groundwater contaminants. To increase the oxidative capacity of sodium persulfate, separate physical or chemical activation technologies (activators) have traditionally been combined with the material to increase its contaminant destroying capability. In practice these activators have been specific to four different types: heat, chelated metals, hydrogen peroxide and sodium hydroxide (base), with the use of sodium hydroxide being the most prevalent in environmental remediation. However, the use of these separate activation technologies can have significant drawbacks and generally speaking are inherently complex, expensive and pose certain health and safety risks - including pH affects and exothermic reactions. A new catalyzed persulfate technology has recently been developed that effectively reduces the complexity and potential hazards associated with activated persulfate. Catalyzed persulfate offers remediation practitioners an all-in-one (activator and oxidant built-in) replacement for traditionally applied sodium persulfate with oxidation performance equivalent to best alternative persulfate activation methods. This new technology also provides users with a relatively safe and easy to apply reagent with minimal heat generation. Finally, catalyzed persulfate also employs a unique and patented surface mediated oxidation process that allows liquid-phase oxidant and contaminant reactions to take place on a heterogeneous catalytic surface. This unique surface mediated process enables several advantageous contaminant-reducing functions including: the generation of sulfate radicals and other oxidizing species, acceleration of chemical oxidation through the adsorption of contaminant molecules and other oxidizing species and catalyzed direct and free-radical-mediated oxidation by sodium persulfate. This presentation will discuss the results obtained from several field application sites where catalyzed persulfate was used and a brief review of the technology itself.

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Presenting Author: Danny Nunez
Alternative Air Sparge Test Method Using SF6

Jason Phillips, Megan Royal and Chris Michalek

A former petroleum storage/distribution terminal was evaluated for remedial alternatives. Air sparge (AS) was identified as a potentially effective remedy for residual soil and groundwater impact. A pilot study was conducted that focused on determining parameters to maximize the effective radius of influence (ROI) and distribution of oxygen in the subsurface. Study infrastructure included an AS injection point and 32 monitoring points. Several test methods were used to evaluate ROI, including dissolved oxygen (DO) monitoring, and injection of sulfur hexafluoride (SF6) as a tracer to simulate DO.

SF6 is a chemically inert gaseous compound that is widely used in the heating, ventilation, and air conditioning industry as a tracer gas. SF6 has a very low solubility, mimicking that of DO solubility in groundwater, but unlike DO, SF6 has no natural demand to overcome. Due to these properties, the use of SF6 as an AS tracer gas was further evaluated as a cost effective substitute for traditional DO monitoring tests. While the SF6 AS tracer technique is not new, limited information was available for practical field applications. Although SF6 is recognized as a potent greenhouse gas, carbon footprint calculations indicate that SF6 AS tests have a smaller carbon footprint compared to that of traditional long-term AS DO monitoring tests.

An extended DO monitoring test was conducted that continuously monitored DO concentrations in groundwater for weeks during a pulsed AS injection. A SF6 test was then completed to compare to the DO monitoring results. Groundwater samples were collected and analyzed on-site by a mobile laboratory using a gas chromatography with mass spectrometry technique. Overall study results show that SF6 tracer tests are potentially a cost effective and valid substitute for long-term AS DO monitoring tests.

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Presenting Author: Jason Phillips
Model for Compound Specific Isotope Analysis (CSIA) of Chloro-ethene Results to Produce Data Interpretable with First-Order, Rayleigh Kinetics

Patrick W. McLoughlin, Robert J. Pirkle, Aaron D. Peacock, John T. Wilson, Richard W. McCracken

CSIA was used at the former England Air Force Base in Louisiana (fEAFB) to answer questions about the effectiveness of the MNA remedy. In this work a kinetic model used the TCE, cis-DCE and VC concentrations and δ^{13}C to calculate the concentration and δ^{13}C of a virtual parameter (ClEB) that could be described with single step first-order and Rayleigh kinetics. That model was chosen based solely on its ability to describe laboratory data. That model was used to predict degradation rates for fEAFB. A history of concentration monitoring was used to measure the observed attenuation rate at fEAFB. The predictions are always conservative, with the observed attenuation rate being greater than the predicted degradation rate by a factor ranging from 4.3 to 46 with a median of 12. The assumptions necessary to make those predictions are discussed. The largest source of error is that a single release is responsible for the contamination. This is corroborated by findings of site characterization efforts that concluded the fEAFB contaminants were the result of multiple, small releases over a prolonged period of time. Rather than focusing upon rate constant determinations the ClEB δ^{13}C was combined with the historical concentration data to produce a graph which showed wells where there was a likely ongoing source, wells where reductive dechlorination was the dominant mechanism, and wells where the observed attenuation could not be mostly ascribed to reductive dechlorination but was also influenced by either oxidation or non-destructive attenuation mechanisms such as dilution.

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Presenting Author: Patrick W. McLoughlin
Combined Remedies for Rapid Remediation of Chlorinated Solvents - Synergies, Results, and Lessons Learned

Christopher Gale, Brian Hitchens, Sam Williams and Doug Riddle

This study presents the results and implementation challenges of a project involving the concurrent implementation of enhanced in-situ bioremediation (EISB), soil vapor extraction (SVE), and electrical resistive heating (ERH) to remediate chlorinated solvent and fuel hydrocarbon impacts associated with a former manufacturing facility. ERH with dual phase extraction was implemented for approximately 7 months in an approximately 4,500 sq ft source area where DNAPL and LNAPL had been identified in low permeability soils. SVE and EISB were implemented to treat vadose zone impacts and the dissolved phase groundwater plume outside of the source area. This integration of multiple remedial technologies has exhibited synergetic effects including: enhanced EISB efficiency in the saturated zone immediately adjacent to the ERH treatment zone due to increased temperatures and generation of bio-available carbon source by-products during ERH operations.

Implementing these technologies concurrently presented additional challenges beyond those commonly encountered. These challenges included resurfacing of injectate solution through wells and probes installed for the SVE and ERH programs; damage to at least one of the SVE wells installed near the ERH treatment due to temperature generated during ERH operations; and increased vinyl chloride concentrations in groundwater extracted during ERH operations.

This integrated approach has successfully achieved the project goal for rapid remediation of this chlorinated solvent site. Within 7 months of ERH operations, remedial action objectives were achieved in the source area. Remedial action objectives were achieved using SVE and EISB in less than one year for low concentration portions of the site. Since completion of EISB injections in January 2012, concentrations of COCs in groundwater at the site have decreased by multiple orders of magnitude and are below MCLs in many wells. This presentation will provide a summary of project results as well as an evaluation of the synergies and lessons learned from combining remedies.

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Presenting Author: Christopher Gale
Magnetic Susceptibility to Verify Zero-Valent Iron (ZVI) Distribution in Subsurface Soil

Nathan Diem, Tina Pham and Vibhav Mankad

Conestoga-Rovers and Associates (CRA) implemented in-situ chemical reduction (ISCR) for treatment of trichloroethene (TCE) in soil and groundwater at a site located in Mountain View, California. The distribution of injected EHC® containing zero-valent iron (ZVI) was evaluated using magnetic susceptibility (MS). MS is a novel method to directly measure the distribution of ZVI in subsurface soil. MS measurements indicate the degree of magnetization of a material in response to an applied magnetic field and can be used as a relatively simple and accurate method to quantify the distribution of EHC® in subsurface soil.

EHC® was injected between 7 and 18 feet below ground surface using direct-push technology and a top-down approach. The target depth interval consisted of 2- to 3-foot thick sand channels separated by silts and clays. Confirmation soil cores were collected in acetate liners and scanned with a Bartington Model MS3 meter and MS2K sensor every six inches to measure MS throughout the core. The MS2K sensor operates by generating a low frequency, low intensity, magnetic field around the sensor. Confirmation soil cores were collected to verify both pre-injection and post-injection MS levels. Qualitative verification was conducted through visual observation of the confirmation soil cores which were left exposed to the atmosphere for over 24 hours to allow for identification of reddish-brown oxidized iron.

To correlate the MS readings to the amount of injected ZVI, CRA created standards of 0%, 10%, 20%, 50%, 75%, and 100% EHC® material in soil. The standards were created by mixing a designated weight of EHC® material with a designated weight of soil. MS readings were measured for each of the standards and plotted to find a polynomial line of best-fit. The MS readings from confirmation soil cores were converted to percent EHC® values using the best-fit equation. MS readings were used to evaluate the vertical distribution and radius of influence of ZVI in the target depth interval.

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Presenting Author: Nathan Diem
PETROLEUM BIODEGRADATION METABOLITES IN GROUNDWATER: NEW INSIGHTS AND THEIR SIGNIFICANCE

New Results: Comparison of Petroleum Biodegradation Metabolites in Groundwater at Service Stations vs Terminals
Dawn Zemo, Zemo & Associates, Inc., Incline Village, NV; Rachel Mohler, CETC, Richmond, CA; Asheesh Tiwary, CETC, Houston, TX; Kirk O’Reilly and Sungwoo Ahn, Exponent, Inc., Bellevue, WA; Renae Magaw and Karen Synowiec, CETC, San Ramon, CA

Exploratory Analysis of Petroleum Biodegradation Metabolites Using GCxGC
Rachel Mohler, Chevron Energy Technology Company (CETC), Richmond, CA; Dawn Zemo, Zemo & Associates, Inc., Incline Village, NV; Kirk O’Reilly and Sungwoo Ahn, Exponent, Inc., Bellevue, WA; Renae Magaw and Karen Synowiec, CETC, San Ramon, CA; Asheesh Tiwary, CETC, Houston, TX

Petroleum Biodegradation Metabolites: A Biochemist’s Perspective
Kirk O’Reilly and Sungwoo Ahn, Exponent, Inc., Bellevue, WA; Dawn Zemo, Zemo & Associates, Inc., Incline Village, NV; Rachel Mohler, CETC, Richmond, CA; Asheesh Tiwary, CETC, Houston, TX; Renae Magaw and Karen Synowiec, CETC, San Ramon, CA

Evaluation of Potential Aquatic and Human Toxicity of Petroleum Biodegradation Metabolites
Asheesh Tiwary, CETC, Houston, TX; Sungwoo Ahn and Kirk O’Reilly, Exponent, Inc., Bellevue, WA; Renae Magaw and Karen Synowiec, CETC, San Ramon, CA; Rachel Mohler, CETC, Richmond, CA; Dawn Zemo, Zemo & Associates, Inc., Incline Village, NV

Life-Cycle of a “TPHd/DRO” Plume
Dawn Zemo, Zemo & Associates, Inc., Incline Village, NV; Rachel Mohler, CETC, Richmond, CA; Asheesh Tiwary, CETC, Houston, TX; Kirk O’Reilly and Sungwoo Ahn, Exponent, Inc., Bellevue, WA; Renae Magaw and Karen Synowiec, CETC, San Ramon, CA
New Results: Comparison of Petroleum Biodegradation Metabolites in Groundwater at Fuel Terminals (with no or very low GRO/BTEX plumes) vs. Service Stations (with elevated GRO/BTEX plumes)

Dawn A. Zemo, Rachel E. Mohler, Asheesh K. Tiwary, Kirk T. O’Reilly, Sungwoo Ahn, Renae I. Magaw, Karen A. Synowiec

Metabolite families and structural classes in groundwater sample extracts from five fuel terminals and five service stations (SS) have been identified using GCxGC-MS. Groundwater at all terminals had no or very low concentrations of GRO/BTEX, indicating a highly biodegraded condition. The metabolites mixtures at the terminals show a sequential oxidation maturity, with a per-sample average of relatively high proportion of organic acids/esters, about equal proportions of alcohols and ketones, and very few phenols and aldehydes. The structural class with the highest per-sample average percentage at the terminals was straight and branched (alkyl) acids/esters. In 2013 groundwater samples were collected from the smear zone at SS sites with residual gasoline product and elevated concentrations of dissolved GRO/BTEX to evaluate whether the relative proportions of the metabolite families and structural classes were similar to the terminals. SS site average results show that for samples without separate-phase product, alcohols were the highest proportion of the metabolite families identified (37%), followed closely by ketones (31%) and then acids/esters (21%), and that few aldehydes (7%) and phenols (4%) were identified. The structural classes with the highest per-sample average percentage at the SS sites were straight and branched (alkyl) alcohols, followed closely by (alkyl) acids/esters, (alkyl) cyclic ketones, and (alkyl) cyclic alcohols. The GCxGC results show that the metabolites in groundwater within these GRO/BTEX plumes are in a “less-mature” sequential oxidation state than at the terminals. This is attributed to the high concentrations of residual product and dissolved hydrocarbons present, and thus more activity involving the initial oxidation steps from hydrocarbon to metabolite. The vast majority of the metabolites identified in groundwater at the terminals and at the SS sites are in structural classes ranked as Low toxicity to humans.

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Presenting Author: Dawn A. Zemo
Exploratory Analysis of Petroleum Biodegradation Metabolites Using GCxGC

Rachel E. Mohler, Dawn A. Zemo, Kirk T. O'Reilly, Sungwoo Ahn, Asheesh K. Tiwary, Renae I. Magaw, Karen A. Synowiec

It has been known since the mid-1990s that complex mixtures of polar compounds were present in groundwater at sites with biodegrading fuel sources, but identifying many individual compounds within the mixture (without derivatization to analyze only for certain groups) was not possible using traditional GC-MS. In order to elucidate the composition of complex mixtures of hundreds to thousands of organic compounds in groundwater, advanced separation technologies are required. The objective of this research was to develop an exploratory comprehensive two dimensional gas chromatography coupled to time of flight mass spectrometry (GCxGC-TOFMS) approach to characterize petroleum metabolites in groundwater samples collected from fuel release sites. The metabolites varied between the sites and the GCxGC method tentatively identified over 1700 unique polar compounds in the sample extracts including acids/esters, alcohols, phenols, ketones, and aldehydes from 43 groundwater samples collected at five fuel terminals and 18 groundwater samples collected at five service station sites. GCxGC not only provides a better separation over traditional GC approaches, but it also improves detection limits and the potential to identify unknown compounds. The technique, method detection limits, and separation patterns will be described in this presentation.

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Presenting Author: Rachel E. Mohler
Petroleum Biodegradation Metabolites: A Biochemist’s Perspective
Kirk T. O’Reilly, Sungwoo Ahn, Dawn A. Zemo, Rachel E. Mohler, Asheesh K. Tiwary, Renae I. Magaw, Karen A. Synowiec

Biodegradation research typically focuses on compounds for which standards are available. For petroleum hydrocarbons these include non-substituted and minimally branched alkanes and aromatics. In this study, the results of non-targeted GCxGC-MS analysis of groundwater from fuel release sites tentatively identified over 1700 unique metabolites of petroleum degradation. While collected from anaerobic portions of plumes, these were dominated by classes of compounds, including ketones, alcohols, and monocarboxylic acids, associated with aerobic degradation. Dicarboxylic benzyl- and alkylsuccinates, considered to be important indicators of anaerobic degradation, were not identified. An unexpected finding was the large number of esters detected. The carbon structures are consistent with those found in distilled fuels and include numerous branched and cyclic compounds. While the result of hydrocarbon metabolism, the compounds identified are similar to those found in other biologically produced solutions such as fruit juices and distilled spirits. This presentation will discuss how the results inform our understanding of petroleum degradation.

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Presenting Author: Kirk T. O’Reilly
Evaluation of Potential Aquatic and Human Toxicity of Petroleum Biodegradation Metabolites

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Non-targeted GCxGC-MS analyses of groundwater samples from historic fuel release sites have tentatively identified over 1700 unique polar metabolites representing many distinct structural classes of chemicals including acids/esters, alcohols, phenols, ketones, and aldehydes. The potential toxicity of these metabolites to aquatic and human receptors has been investigated. To evaluate the potential aquatic toxicity of these metabolites, upgradient (representing local background conditions) and downgradient groundwater samples were collected from biodegrading fuel sites and submitted to a laboratory for chronic aquatic toxicity testing using EPA test methods 1000 (Fathead Minnow), 1002 (Daphnid) and 1003 (Green Algae). Test results show that there is no difference in observed toxicity between upgradient (background) groundwater samples free of polar metabolites and downgradient samples containing polar metabolites. This result suggests that any aquatic toxicity observed in these studies primarily arose from background water quality. Evaluation of potential human toxicity of the polar metabolites was based on the USEPA Reference Doses (RfDs) of representative chemicals for each structural class of polar metabolites. Chemicals with RfDs ≥ 0.1 mg/kg/day were assigned a “Low” hazard ranking; “Low to Moderate” if 0.1 > RfD ≥ 0.01 mg/kg/day, and “Moderate” if 0.01 > RfD ≥ 0.001 mg/kg/day. These three groups included essentially all of the potential polar metabolites for which RfDs were available. This ranking system was applied to polar metabolites identified in groundwater samples collected from biodegrading fuel sites and the results show that the vast majority of the polar metabolites are in structural classes that may present a “Low” toxicity hazard to humans. Overall, the complex mixtures of polar metabolites evaluated are unlikely to present a significant risk to human health or aquatic life. Additional aquatic toxicology and in-vitro human health toxicity testing approaches under consideration will be presented.

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Life-Cycle of a “TPHd/DRO” Plume

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This presentation demonstrates the sequentially-changing components of a “diesel-range organics” groundwater plume in time and space at sites with biodegrading fuel sources. The decreasing effective solubility of petroleum fuel sources with increasing residence time, and the sequential oxidation reactions that occur during aerobic or anaerobic biodegradation of petroleum hydrocarbons are well understood and are documented in this work. When a petroleum source is relatively unweathered, and thus is still an active source of dissolved hydrocarbon constituents, the associated “first-stage” organics plume consists primarily of dissolved hydrocarbons and relatively low proportion of biodegradation metabolites. As the source weathers and/or the first-stage plume migrates downgradient, the resulting “second-stage” organics plume consists of mostly metabolites with a minor proportion of dissolved hydrocarbons. Once the source is weathered to the point that hydrocarbons will not measurably partition to the groundwater and/or the second-stage plume migrates further downgradient, the “third-stage” organics plume is composed of 100% metabolites. With migration of the third-stage plume downgradient from the residual hydrocarbons in soil and further biodegradation, the “fourth-stage” organics plume is composed of 100% metabolites dominated by organic acids/esters. Each of these four stages of the diesel-range organics plume will be demonstrated using (1) quantitative analytical results, (2) TPH chromatogram patterns, (3) GCxGC results for the metabolite families, and (4) toxicity rankings based on GCxGC results for metabolite structural classes.

The sequential processes demonstrated by this work are snap-shots in time of the progression of in-situ biodegradation and natural attenuation. An RfD-based evaluation indicates that the mixtures of metabolites at the various stages, but especially at the third and fourth stages, pose low-threat to human health. A separate presentation shows that the metabolite mixtures in groundwater at four sites generally did not cause an increase in aquatic toxicity above background groundwater quality. Non-toxicity factors such as potential odor properties of the identified metabolites will also be discussed.

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Presenting Author: Dawn A. Zemo
PETROLEUM HYDROCARBON VAPOR INTRUSION I

Evaluation of VI Data Relative to Separation Distance Screening Criteria – A Michigan Case Study
Chris Mulry, GES, Inc., Odenton, MD

Ensuring Occupational Worker Safety at Vapor Intrusion Sites
Shukla Roy-Semmen, Chawn Jeng, and William Bosan, California EPA, DTSC, Cypress, CA; Frank Parr, DTSC, Chatsworth, CA

Results from an EPA Research Program on Temporal Variations: Ramifications on Soil Gas & Indoor Air Sampling Issues
Blayne Hartman, Hartman Environmental Geoscience, Solana Beach, CA; Brian Schumache and John Zimmerman, EPA-ORD (NERL), Las Vegas, NV; Christopher Lutes and Brian Cosky, ARCADIS, Durham, NC

Is There a Case to be Made for Background Levels of Benzene in Sub-slab Soil Gas?
Katherine Butler, Kathleen Souweine, and Charles Lambert, McDaniel Lambert, Inc. an Intrinsik Company, Venice, CA

Unexpected Sources for Indoor Air Benzene Levels
Suzie Nawikas and Louise Adams, H&P, Inc., Carlsbad, CA; G. Todd Ririe, BP, La Palma, CA; Blayne Hartman, Hartman Environmental Geoscience, Solana Beach, CA

Speciation of C5 to C12 Aliphatic Hydrocarbons and C6 to C12 Aromatic Hydrocarbons using EPA Method 8260 for Vapor Intrusion Risk Assessment Evaluations
Steve Jones, Jones Environmental Laboratories, Fullerton, CA
Evaluation of VI Data Relative to Separation Distance Screening Criteria – A Michigan Case Study

Chris Mulry

An examination of Michigan’s Petroleum Vapor Intrusion (PVI) guidance and practice will be presented through evaluation of data from approximately 50 UST cases located in various settings across the state. The data and likely case outcomes relative to VI pathway completion will be discussed relative to approaches and actions that would likely result from use of source strength and distance screening criteria being offered in draft USEPA and ITRC PVI guidance documents – both expected to issue in 2014. The Michigan data analysis will be presented in a framework to include regional geology, state guidance and practical practice considerations. In addition, work effort and results will be presented to compare the recommended state approach to the generic screening method relative to a state-approved pathway elimination determination and costs to complete this pathway analysis.

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Presenting Author: Chris Mulry
Ensuring Occupational Worker Safety at Vapor Intrusion Sites

Shukla Roy-Semmen, Frank Parr, Chawn Y Jeng and Willaim Bosan

We routinely encounter active Resource Conservation and Recovery Act (RCRA) facilities where volatile organic compounds (VOCs) are found to be present at significant concentrations, in the subsurface. Preliminary evaluation of these data for vapor intrusion (using the Johnson and Ettinger model) indicates that cancer risks to onsite workers often exceed USEPA’s acceptable risk range of 1 in a million to 1 in 10,000. Request for indoor air sampling at some of these facilities has been met with resistance from the facility owners, who state that all onsite workers are regulated under the authority of California Occupational Safety and Health Administration (CalOSHA), and hence only OSHA's Permissible Exposure Limits (PELs) are the relevant standards for monitoring worker safety. OSHA’s PELs are typically 2-3 orders of magnitude higher than USEPA’s acceptable levels of VOCs in ambient and indoor air. Furthermore, it has been suggested that neither USEPA nor the state regulatory agencies have the authority to regulate worker safety under these circumstances. However, communications with California OSHA personnel indicate that typically facilities are inspected only when there are reports of accidents/injuries or complaints of unsafe working conditions. In this presentation, we will discuss circumstances where OSHA PEL use may or may not be appropriate at various stages of the site investigation and cleanup process. We will also discuss the steps that should be taken to ensure worker safety. For example, site health and safety plans should be reviewed by the oversight agency's industrial hygienists. Appropriate air monitoring and personnel monitoring data should be collected for comparison to OSHA’s PELs.

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Results from an EPA Research Program on Temporal Variations: Ramifications on Soil Gas & Indoor Air Sampling Issues

Blayne Hartman, Brian Schumacher, John Zimmerman, Christopher Lutes, Robert Truesdale and Brian Cosky

Research studies funded by EPA-ORD (NERL) on temporal variations in indoor air, soil gas and sub-slab soil gas concentrations at a duplex in Indianapolis began in early 2011 and continued into 2013. The preliminary findings from this study were presented at the March 2012 and 2013 AEHS conference in San Diego.

One part of the program consisted of a continuous monitoring instrument that sampled vapor from 12 to 14 locations consisting of indoor air, soil gas and sub-slab soil gas probes. Each location was sampled approximately once every 60 to 90 minutes continuously over a 3 month in 2011, 2.5 months in 2012 and 2.5 months in 2013. The collection covered periods of warm and cold temperature, rain, and snow.

The continuous monitoring data will be presented and discussed in this talk. The focus will be on ramifications from the data on sampling related issues, such as how long to collect sub-slab soil gas samples (grab vs. time integrated), how long to collect indoor air samples (grab? 24-hour? 7 days? 21-days?), is it necessary to resample soil gas and indoor air samples, etc.

This will be the first public presentation of this data evaluation.

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Is There a Case to be Made for Background Levels of Benzene in Sub-slab Soil Gas?

Katherine Butler, Kathleen Souweine, and Charles Lambert

Sub-slab soil vapor sampling for TPH-impacted sites has been an important component of risk assessments in California for the last decade. There has been an increasing trend to use multiple lines of evidence, including soil gas, sub-slab soil gas, indoor and ambient air samples, to determine the completeness of the vapor intrusion pathway. This has contributed to an abundance of data for contemporaneous sub-slab soil gas, indoor and ambient air samples for two residential communities in California – one in a coast area of Southern California and one located further inland in Central California. In addition, the recent change in the DTSC sub-slab to indoor air attenuation factor from 0.01 to a more protective value of 0.05 has caused more sensitive reporting limits and detection of very low levels of benzene among these data available. Statistical evaluations have concluded that background concentration ranges for common TPH-related compounds (e.g. benzene) in sub-slab soil gas exist. Sub-slab soil gas concentrations found in residential properties were not correlated with proximity to source area. For the coastal residential community in Southern California, a background threshold value of 16.7 µg/m³ was established for benzene; this corresponds to a residential cancer risk that exceeds the lower end of the USEPA risk management range (10⁻⁶). Our conclusions from the sub-slab data collected in two residential communities near petroleum contamination, as well as our experience at other sites, is that sub-slab soil vapor data need to be closely examined with respect to possible background levels. Additional research is needed to explain the chemical transport of background volatile organic compounds into sub-slab.

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Presenting Author: Katherine Butler
Unexpected Sources for Indoor Air Benzene Levels

Suzie Reed Nawikas, G. Todd Ririe, Blayne Hartman, and Louise A. Adams

Hydrocarbon vapor intrusion investigations are designed to evaluate if the VI pathway is complete, and there are times when sampling indoor air is a part of these investigations. Although it is widely recognized that sampling indoor air is problematic, it is often either required or necessary in order to determine if hydrocarbon vapor intrusion is occurring within a building or residence. Prior to the collection of indoor air samples, all potential sources of hydrocarbons are to be removed from the building/residence to be sampled. In addition, the residents or workers in the building are advised to avoid using or introducing any new potential sources of hydrocarbons during the sampling event.

As a result of conducting a number of indoor air sampling investigations, we have encountered instances where benzene and other hydrocarbons can be traced back to sources or events that were not anticipated. Some of these unanticipated events include: homeowner fondue parties with Sterno during the sampling timeframe, and leaking natural gas pipelines at the property. In addition, we have found that a number of common household products can act as sources of measurable levels of benzene and other hydrocarbons, potentially contributing to indoor hydrocarbon levels. Some of these unexpected sources include: dishwasher detergents, shaving cream, baby wipes, modeling clay, and children’s toys.

With the benzene action limits set at a level that maintains a less than one in a million cancer risk, it is often not possible to have indoor air benzene levels measured low enough to meet these criteria. Aside from always collecting a background ambient air sample during the sampling event, it is also recommended that all potential hydrocarbon sources, including leaking natural gas pipelines, be evaluated prior to the collection of any indoor air samples. If nothing else, these sources can be identified and used in the interpretation of the investigation.

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Speciation of C5 to C12 Aliphatic Hydrocarbons and C6 to C12 Aromatic Hydrocarbons using EPA method 8260 for Vapor Intrusion Risk Assessment Evaluations

Steve Jones

As more and more firms are switching from Freon and Chlorinated hydrocarbons in order to continue operations, the general trend is to switch to hydrocarbon based materials. The restricted use of tetrachloroethylene (PCE) in dry cleaners has led most of these establishments to resort to hydrocarbon cleaning apparatuses. Many propellants are now hydrocarbon based as well as many cleaning solvents. Many other applications such as paint thinners/solvents, paints, household supplies and others are switching to hydrocarbon bases because these mixtures have lower costs and risk levels than the compounds or mixtures that they are replacing.

Several states including California have adopted risk assessment values for aliphatic and aromatic hydrocarbon ranges. California recently retracted their VIMA document that included these risk values primarily due to a lack of analytical procedures to measure individual carbon ranges. A simple, easy to use, readily available procedure exists to measure each parameter using common EPA method 8260 technology. A narrative will be given discussing how numbers can be obtained for each aliphatic and aromatic category.

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PETROLEUM HYDROCARBON VAPOR INTRUSION II

New EPA Method of Vapor Sample Collection Confirms Attenuation of Subsurface Petroleum Hydrocarbon Vapors in Lateral Direction
Robin Davis, Utah Department of Environmental Quality, Salt Lake City, UT

Vapor Intrusion Risk Communication
Mary McDaniel, McDaniel Lambert, Inc. an Intrinsik Company, Venice, CA

A Rational Approach to Methane Hazard Assessment
John Sepich, Brownfield Subslab, San Antonio, TX; Stephen Marsh, McKenna Long & Aldridge, San Diego, CA

Vapor Intrusion of Methane – The Challenge of Screening Out Low-Risk Sites
George DeVaull, Shell Global Solutions US, Inc, Houston, TX; Lila Beckley, GSI Environmental, Austin, TX; Bart Eklund, URS Corporation, Austin, TX; John Sepich, Brownfield Subslab, San Antonio, TX

CO2 Flux Measurements to Estimate Natural Source Zone Depletion – State of the Practice and Method Validation using Modeling
Ian Hers, Golder Associates Ltd., Burnaby, BC, Canada

Use of Temperature to Determine the Relative Rate of Biodegradation in the Vadose Zone
G. Todd Ririe, BP, La Palma, CA

Using Temperature Measurements in Conjunction with PVI and SZNA Biodegradation Models
Robert Sweeney, Environmental & Petroleum Geochemistry, Etna, CA
New EPA Method of Vapor Sample Collection Confirms Attenuation of Subsurface Petroleum Hydrocarbon Vapors in Lateral Direction

Robin V. Davis

Theoretical diffusion of petroleum vapors indicates that attenuation of petroleum hydrocarbon (PHC) vapors in the lateral direction occurs in shorter distances and at deeper depths than in the vertical direction. However, determining the distance of attenuation in the lateral direction is difficult because of the high uncertainty of knowing the location of the lateral edge of contamination.

EPA’s new method of vapor sampling helps determine the edge of contamination because vapor samples are collected from existing groundwater monitoring wells that have some portion of the well screen above the water table. While installing multi-depth vapor probes is still important for evaluating vertical attenuation and potential impacts to overlying receptors, the new EPA method helps reduce the costs of installing additional probes that would be needed for defining the edge of contamination.

This new method was tested at the Hal’s Service, Green River, Utah field study site by comparing vapor samples collected from multi-depth vapor probes to vapor samples collected from conventional groundwater monitoring wells. The field study results show a positive comparison and can therefore be used to determine vapor impacts to receptors laterally from the contaminant source. The results of this study also show that PHC vapors attenuate laterally in about the same distance as they do vertically.

EPA’s has determined that vapors associated with LNAPL sources attenuate within 15 vertical feet of an LNAPL source. This study supports the use of 15 feet for vapor attenuation in both vertical and lateral directions for LNAPL sources.

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Vapor Intrusion Risk Communication

Mary F. McDaniel

How do you tell a community that there is a potential risk of exposure to toxic solvents because they are slowly seeping up through the foundation of their homes? While it is never easy to explain the problems and the solutions of impacted soil or groundwater, discussing the risk of inhaling solvents that have migrated into a home is a more daunting task.

The technical aspects of soil vapor monitoring are well studied and there is significant federal and state guidance to help responsible parties through remediation projects. However, risk communication, although often required by regulatory agencies, is unfamiliar, avoided and often times skipped altogether. Scientists and engineers are often surprised to find that technical data is one of the least compelling factors when communicating risk, and they can be blindsided by the futility of using only logic and data. Considering that outraged stakeholders can stall projects, change work plans, increase budgets, expose companies to negative publicity and cities to losses in revenue, more energy should be focused on risk communication at vapor intrusion sites.

Over the last decade we have been at the forefront of communicating the results of vapor intrusion studies to concerned households, oversight agencies and other stakeholders. Because sites differ in their cultural makeup, economic health and history, as well as the chemicals of concern, there is no single formula for community outreach that works across all sites. However, from our experience, we will discuss risk communication and community outreach techniques that have been successfully honed on the front lines. We will use positive and negative case studies to illuminate these theories in practice.

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A Rational Approach to Methane Hazard Assessment

Stephen Marsh and John Sepich

Phase 1 environmental reports identify sites potentially impacted by methane. Phase 2 testing measures methane and other soil vapors. However it is not well understood when methane soil gas actually poses a hazard to structures. Applying confined space methane action levels as soil concentration action levels is overly conservative. Concentration of combustible gas in the soil is only one factor. Volumes of the gas; pressures in the soil; and pathways to receptors are also important. There has been a need for guidance regarding when a site needs no further action, versus when a site needs further study or simply mitigation.

In San Diego County, California some years ago high levels of methane (hundreds of thousands of ppmv) were measured in newly compacted engineered earth fill. In the midst of considerable local media attention, the County quickly adopted a testing and mitigation ordinance but also assembled an ad hoc committee of experts to further study the matter. Based upon this scientific review, the County determined that methane mitigation was not necessary for situations even with relatively high methane concentrations, when the methane was microbial in origin and without significant pressure or volume. The ordinance was repealed. The San Diego experience represented the first time that methane regulations considered actual hazard rather than arbitrary action levels.

In the State of California, the Department of Toxic Substances Control (DTSC) has promulgated a mathematical model for determining risk from microbial methane soil gas, which includes soil gas pressure as one of the calculation parameters. The DTSC model suggests that considerable soil gas pressure is required for hazard to result inside typical building space. This is consistent with available information regarding actual incidents of fire / explosion in buildings. The DTSC model builds upon and further refines the San Diego findings.

ASTM International is developing a standard practice for evaluating potential hazard due to methane in the vadose zone. This standard will provide a simplified approach for evaluating site methane hazard based upon methane concentrations, volumes, pressures and other factors. Suggested action levels and pressures will reflect actual hazard.

Unlike health risks due to chronic exposure from other soil vapors (i.e. VOC’s), methane poses safety risks during instantaneous exceedances of the lower explosive limit in indoor air. Methane differs from VOC’s in that inherent gas pressure in the soil may result in flows of the gas into confined spaces that far exceed normal diffusive - advective phenomena.

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Vapor Intrusion of Methane – The Challenge of Screening Out Low-Risk Sites

Lila Beckley, Bart Eklund, John Sepich, and George DeVaull

Background/Objectives. Vapor intrusion investigations often include measurements of methane, oxygen, and carbon dioxide in soil gas, especially at sites with suspected petroleum hydrocarbon contamination. The measurements are intended to characterize the subsurface in terms of its aerobic versus anaerobic nature. However, methane has a flammable range of 5 to 15% by volume in air and therefore methane itself can pose a hazard. In addition, there are some sites where methane is the primary issue in terms of vapor intrusion, such as redevelopment of sites with large amounts of organic fill material (e.g., mulch, food waste). There are no consistent guidelines in most jurisdictions as to what level of methane in the vadose zone poses a significant risk of explosion or fire. Action levels developed for indoor air (e.g., 20% of the methane LEL) are overly conservative when directly applied to soil gas in the vadose zone. The unintended consequence of measuring methane as part of VI investigations can be to trigger additional investigation or risk mitigation that otherwise would not be necessary. There is a need for a practical and reasonable industry standard for evaluating, prioritizing, and addressing potential methane hazards based upon current scientific and engineering knowledge.

Approach/Activities. A task group under ASTM International has been formed to develop an ASTM Standard for evaluating potential hazard due to methane in the vadose zone. This standard is nearing completion and provides a relatively straight-forward approach to evaluate a site based on methane concentration and volume, along with differential pressure. In this paper, existing regulations and guidance for methane are summarized, along with an overview of the fate and transport of methane in shallow soils. The general conditions that have led to historical methane explosions due to VI are described. The specific types of information that should be collected at a given site to evaluate methane hazard are listed and described. Finally, the decision-making framework for evaluating methane hazard is presented.

Results/Lessons Learned. The evaluation of methane at VI sites is fundamentally different than the evaluation of VOCs and requires a different conceptual site model. Unlike VOCs, there is no fixed starting mass of methane at a site – methane can be generated in situ over time. Unlike VOCs, any methane hazard is acute rather than chronic. The relative importance of diffusive versus advective transport also is a key difference. Methane hazard can be readily evaluated, but only if the necessary information is collected during VI investigations.

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CO2 Flux Measurements to Estimate Natural Source Zone Depletion – State of the Practice and Method Validation using Modeling

Ian Hers and Parisa Jourabchi

The quantification of natural source zone depletion (NSZD) of petroleum hydrocarbons is important for an evaluation of the longer term impacts and potential risks associated with light non aqueous phase liquid (LNAPL). Such evaluations may be used to inform studies of LNAPL mobility and longevity of dissolved and vapour-phase plumes. A promising new technique for NSZD studies are surface or near surface measurements of the upward carbon dioxide (CO2) flux. When the CO2 flux is from aerobic and/or anaerobic biodegradation of source zones, the technique can be used to estimate rates of degradation or depletion of a LNAPL source. There are two techniques used for estimation of CO2 flux, static CO2 traps and dynamic chambers where CO2 is measured, and where often 14C is quantified as an ancillary measurement to determine the CO2 source. Although data are relatively limited, published studies of CO2 flux suggest potentially high source depletion rates at sites evaluated. There are, however, questions on the flux measurement protocol including influence of soil properties and surface cover.

To address these questions and provide for a more in-depth understanding of this method, a review of available literature is conducted including data where the static and dynamic techniques are compared. In addition, the MIN3P-Dusty numerical model is used to simulate soil gas fluxes (including methane and carbon dioxide) for a one-dimensional soil column with varying LNAPL sources, including gasoline with varying ethanol contents, and different soil properties and surface cover conditions. The advantage of model simulations is that soil gas fluxes can be quantitatively linked to mass source depletion rates from biodegradation (including ethanol degradation under anaerobic conditions), volatilization, and potentially other mass reduction processes (e.g., dissolution). For select sites, the MIN3P-Dusty simulations are compared to field CO2 flux measurements. A methodology for use of models to inform field CO2 flux measurements is presented.

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Presenting Author: Ian Hers
Use of Temperature to Determine the Relative Rate of Biodegradation in the Vadose Zone

G. Todd Ririe

Aerobic biodegradation of hydrocarbons utilizes O₂ and produces CO₂, releasing heat during the process. The amount of heat released from hydrocarbon oxidation is a function of the rate of biodegradation and amount of hydrocarbons degraded. For soil, the heat released from biodegradation is, in part, used to raise the temperature of the soil and, in part, lost by thermal conductance through the soil. The thermal anomaly (ΔT) developed in the soil due to biodegradation can be large enough to be documented by in situ temperature measurements easily using readily available equipment. Based on temperature measurements made at several BP sites with hydrocarbon spills, ΔT can be used to document source zone natural attenuation (SZNA) as a result of oxygen diffusing through soil from the atmosphere. These data can also be used to provide another line of evidence to support the importance of in situ biodegradation of upward migrating petroleum hydrocarbon vapors.

The vapor transport model used for SZNA evaluation is basically the same as used in PVI models. The subtle differences between the models relate to the type of product in the soil and the depth in the soil (aerobic/anaerobic boundary) where most of the biodegradation is occurring. The rate of biodegradation calculated from vapor transport models, in general, infers the ‘effective’ rate of oxygen transport through the soil based on soil properties and the air diffusion coefficient for oxygen. The error in the calculation can be quite significant. In contrast, the ΔT approach is much less sensitive to soil properties than oxygen diffusion. As a result, the ΔT approach may provide an alternative method for field testing PVI models, and/or previewing sites for potential PVI risk. The benefits of the ΔT approach is that it is non-intrusive (uses existing monitoring wells) and incurs minimum field expense. The approach, however, does have limitations that are presently being evaluated by field-testing under a variety of environmental conditions.

The main limitation for using temperature to document biodegradation in shallow soil is accounting for the annual temperature variation due to atmospheric temperature fluctuations. The atmospheric effect can be eliminated by collecting temperature measurements at the same time at ‘source’ and nearby ‘background’ locations. For this ‘snap-shot’ approach, in situ temperature measurements are made down pre-existing wells. For more comprehensive site evaluation, temperature sensors can be placed at various depths in the well, and temperature measurements made periodically for time spans up to one year.

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Using Temperature Measurements in Conjunction with PVI and SZNA Biodegradation Models

Robert E. Sweeney

The objective of this presentation is to show how temperature measurements made down existing wells can be used in conjunction with *in situ* biodegradation models to aid evaluate depth, areal extent, and relative magnitude of biodegradation of petroleum hydrocarbons in the soil. During aerobic biodegradation, the rates of petroleum and O₂ loss and CO₂ and heat production are all related. Heat generated from the reaction is initially used to raise the temperature of the soil, and then dispersed by heat transport processes. A thermal anomaly (deltaT) will be developed in the biodegradation layer of the soil. The magnitude of deltaT can be used to estimate the minimum rate of biodegradation in the soil. For sites where *in situ* bioremediation is being carried out by soil vapor extraction (SVE) or air sparge (AS), temperature measurements can be used to identify the depth and areal extent of biodegradation in the soil. By comparison of deltaT between wells from areas of active remediation to deltaT from wells in areas without remediation, the effectiveness of remediation for enhancing the rate of biodegradation can be evaluated.

The general conceptual model for using temperature measurements to evaluate biodegradation processes will be presented. Field data will be shown to illustrate the method for collecting temperature measurements and approaches for identifying temperature anomalies (i.e. deltaT) in the soil due to biodegradation. An example will be presented where deltaT is used to evaluate the effectiveness of SVE for enhancing the rate of biodegradation over that for normal natural attenuation processes. Another example will be shown where the rate of biodegradation induced by air sparge was sufficient to create a temperature anomaly of 55 degrees C, thus shifting microbiological activity from mesophilic to thermophilic processes. A final example will be presented where temperature measurements are used to aid evaluate methane transport from groundwater through the vadose zone.

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REMEDIATION

Post ISCO Evaluation of TCE Degradation in Sydney Clays via Compound Specific Isotope Analysis and Microbial Analysis
Brian Tripolone and Shelley Howard, AECOM, Houston, TX; Paul Dombrowski, AECOM, Wakefield, MA; Rachael Casson, AECOM, Sydney, NSW, Australia

Implementation of the Low Threat Petroleum Underground Storage Tank (UST) Closure Policy at Non UST Sites in Santa Barbara County
Paul McCaw, Santa Barbara County Public Health Department, Santa Maria, CA; Chuck Lambert, University of California, Irvine, CA; Katherine Butler, McDaniel Lambert, Inc., Venice, CA; Rebecca Countway, McDaniel Lambert, Inc., Brunswick, ME

Beyond Dredging: The Evolution of Alternative Remedial Options for Contaminated Sediments
Brian Hitchens and Christopher Lieder, Geosyntec Consultants, San Diego, CA

Use of Treatability and Pilot Testing for Comparative Evaluation of Chemical Reduction, Bioremediation, and Chemical Oxidation Technologies at Buckley Air Force Base, Colorado
Post ISCO Evaluation of TCE Degradation in Sydney Clays via Compound Specific Isotope Analysis and Microbial Analysis

Brian Tripolone, Shelley Howard, Paul Dombrowski and Rachael Casson

Groundwater beneath an active warehouse west of Sydney, New South Wales, Australia contained chlorinated volatile organic compounds (VOCs), primarily trichloroethene (TCE) up to 52 mg/L. Shallow soils beneath the site comprise fill materials, plastic silty clays and occasional gravelly clay lenses, with hydraulic conductivity values between $8.8 \times 10^{-9}$ to $1.8 \times 10^{-6}$ cm/s, consistent with clay soils overlying the Wianamatta shale formation observed in this region. Although low soil permeability had previously been regarded as a potential impediment to selection of in-situ injection technologies, analyses of groundwater and continuous core soil samples indicated that dissolved trichloroethene was primarily located in narrow bands of relatively higher permeability materials. After evaluation of injection via direct push versus injection well methods within a targeted treatment area, an array of 18 injection wells was installed on a closely spaced grid, and design volumes of potassium permanganate solution were successfully injected.

Two rounds of potassium permanganate injection were performed, and VOC concentration, compound specific isotope and microbial analyses were carried out before, between and after the injection events. Compound specific isotope analysis enabled the progress of abiotic and biotic degradation to be tracked after each injection round, and isotope trends were consistent with concentration trends and colorimetric estimates of oxidant consumption. Significant decreases in chlorinated VOC concentrations were observed across the treatment area following each round of injection. Although initial contaminant degradation occurred via oxidation, populations of Dehalococcoides microbes actually increased following injection, and evidence of active reductive dechlorination, including detections of vinyl chloride and ethene, was observed after two rounds of ISCO treatment.

Lines of evidence comprising isotope evidence of degradation coupled to sustained order-of-magnitude TCE concentration decreases to below site specific risk-based cleanup goals, and microbe population increases and activity following the second round of injection demonstrated achievement of site management objectives.

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Implementation of the Low Threat Petroleum Underground Storage Tank (UST) Closure Policy at Non UST Sites in Santa Barbara County

Paul Mccaw, Chuck Lambert, Katherine Butler and Rebecca Countway

Santa Barbara County has many historic and operating petroleum-related properties. The recent California Water Board Low Threat Petroleum UST Closure Policy (LTCP) may be applicable to a number of these sites. The purpose of this guidance is primarily to establish consistent statewide case closure criteria for low-threat petroleum UST sites. There have been questions as to how to implement the guidance at non UST petroleum sites (e.g. oil and gas production sites, above ground storage areas, tank farms, sumps etc.), as suggested in the guidance. Such an implementation requires additional steps and considerations mentioned only briefly in the guidance or not at all. Some of these additional considerations include:

1) If there are ecological concerns/receptors at or near the site.

2) If there are elevated levels of total petroleum hydrocarbon (TPH) that will be left in place in shallow soil or a high likelihood that through development deeper soil impacted by elevated TPH may be brought to the surface where they may provoke stakeholder concern. The LTCP doesn’t address nuisance TPH issues nor does it account for noncancer health effects associated with environmentally persistent petroleum hydrocarbons.

3) The site will be used for residential development or other sensitive receptors (e.g. schools), or such sensitive receptors are located adjacent to the site.

4) One or more metals exceed regional background concentrations (e.g. arsenic, lead, nickel, vanadium).

5) Any site where cumulative cancer or noncancer risk might be significant [e.g. multiple petroleum related chemicals (e.g. toluene, xylenes, trimethylbenzenes, TBA) just at the low threat thresholds or ESLs/RSLs].

In this presentation we will describe a step-by-step process that helps to address these additional concerns and determine when additional site investigation, a human or ecological risk assessment, remedial actions and/or a land use covenant may be required for non UST petroleum sites.

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Beyond Dredging: The Evolution of Alternative Remedial Options for Contaminated Sediments

Brian Hitchens and Christopher Lieder

For decades, the only answer to contaminated sediment remediation has been either dredging or capping. While these remedial measures certainly have a central place as effective sediment management measures, alternative measures for in-situ sediment treatment, stabilization, and mitigation are now increasingly implemented at a wide range of sites. Analogous to the shift from dig and haul or pump and treat to innovative in-situ remediation approaches at land-side sites, sediment remediation technologies are maturing past direct removal to less intrusive remedies which are more tailored for individual site conditions. Often these alternatives provide equivalent protectiveness to the environment but may be more easily implemented, generate fewer greenhouse gas emissions, reduce the volume of material disposed at landfills, or are more cost effective. As these technologies have matured, an expanding list of successful case studies has led to more widespread regulatory acceptance of alternative approaches to sediment management.

This presentation will focus on a range alternative or enhanced management strategies for sediment contamination which may be used as stand-alone measures or as part of an integrated remedy, including:

- Enhanced Monitored Natural Recovery – an augmentation of natural depositional process to improve the quality of shallow sediment in the bio-active zone;
- Active Capping – integration of materials such as activated carbon to bind or remediate contaminants and reduce bioavailability;
- In Situ Bioremediation – Stimulating or enhancing the microbial community in the shallow pore water to more efficiently degrade target contaminants; and
- Thin Layer Isolation Capping – placement of a thin layer, low-permeability zone to reduce contaminant flux through the pore water.

Each of these alternative or enhanced sediment management strategies will be discussed in terms of physical limitations for implementation, types of contaminants that have been successfully addressed, challenges for implementation, regulatory acceptance, cost, and maturity of the technology in implementation for pilot or full-scale designs.

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An evaluation was performed to compare viable groundwater VOC treatment technologies for multiple sites, some with different VOC suites of concern, at Buckley Air Force Base, CO. Initially, a series of treatability tests was performed to evaluate the VOC treatment efficiency of chemical reduction, enhanced bioremediation, and chemical oxidation technologies. The first set of treatability tests evaluated abiotic chemical reduction using multiple doses of zero valent iron (ZVI). A second set of treatability tests evaluated the use of Biogeochemical Reductive Dechlorination (BiRD) technology. BiRD technology involves stimulating indigenous sulfate-reducing bacteria to form iron sulfide minerals, which subsequently reduce chlorinated compounds by pathways similar to those of ZVI. Bioremediation technology using emulsified vegetable oil (EVO) and dairy whey was evaluated to assess the suitability of enhanced reductive dechlorination (ERD) as a supplement to the ZVI approach. By enhancing the reduction potential and sustaining anaerobic conditions, TCE may be degraded more effectively by ERD without accumulation of daughter products. Lastly, chemical oxidation technology was evaluated using stabilized hydrogen peroxide (SHP). The SHP approach was tested on a plume containing carbon tetrachloride and chloroform as well as TCE, to evaluate its destruction efficiency on these recalcitrant compounds and its effect on hexavalent chromium formation.

All four technologies were selected for further evaluation in the field via implementation of a pilot testing program to further identify alternative solutions. Subsurface delivery of the chemical reagents via borehole placement and pneumatic fracturing were evaluated, along with construction of a simulated permeable reactive barrier (PRB) to mitigate offsite migration of VOCs near the property boundary. Important factors evaluated in the pilot testing included the implementation and recurring operational costs, the reaction kinetics, in-situ delivery techniques, and integration of multiple technologies to address all COCs. The results will be incorporated into site specific Feasibility Studies.

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RISK ASSESSMENT

Effect of Di-n-Butyl Phthalate on Neuron Development
Joshua Feng and Roger Acey, California State University, Long Beach, CA; Mark Weiss, Kansas State University, Manhattan, KS

An Empirical Evaluation of Metals Uptake by Blackberry Bushes

Soil Management Program - A University Perspective
Dan Blunk, University of California Santa Cruz, Santa Cruz, CA; Julie Hampel, University of California San Diego, San Diego, CA

Oral Bioavailability and Dermal Absorption of PAHs in Soil: State of the Science and Applications to Risk Assessment
Michael Ruby, Integral Consulting, Louisville, CO; Yvette Lowney, Exponent, Boulder, CO; Steve Roberts, University of Florida, Gainesville, FL; John Kissel, University of Washington, Seattle, WA; Annette Bunge, Colorado School of Mines, Golden, CO; Priscilla Tomlinson, Integral Consulting, Seattle, WA

Estimating Soil and Dust Ingestion through the Blood/Soil/Dust Lead Relationship at the Bunker Hill Mining and Metallurgical Complex Superfund Site in Idaho
Susan Spalinger, TerraGraphics Environmental Engineering, Inc., Moscow, ID; Marc Stifelman, USEPA, Seattle, WA; Ian von Lindern and Mara Thorhaug, TerraGraphics, Kellogg, ID; Lindsay Stanek, USEPA, Research Triangle Park, NC

A Review of USEPA’s New RSLs for Total Petroleum Hydrocarbons
Usha Vedagiri, URS Corporation, Oakland, CA; Kanan Patel-Coleman, URS Corporation, Los Angeles, CA

Recent Trends and Prevention for a Significant Occupational Hazard for Scientists and Engineers and Other Field Workers: Coccidioidomycosis: (Valley Fever)
James Jacobs, Clearwater Group, Point Richmond, CA
Effect of Di-n-Butyl Phthalate on Neuron Development

Joshua Feng, Mark Weiss and Roger Acey

Plasticizers such as di-n-butyl phthalate (DBP) and bisphenol A (BPA) are well documented, ubiquitously distributed environmental contaminants. The effect of these compounds on human health has been controversial. We have developed a human umbilical cord mesenchymal stem cell (HUC-SCs) system as a model to predict relative toxicities of phthalate esters. The default pathway in these differentiating cells is formation of neural tissue. Differentiating cells are exposed to the potential toxin for increasing periods of time, collected, and homogenized. Cell lysates are then analyzed by 2D-PAGE for changes in protein expression. Our first series of experiments looked at the effect of 10 nM di-n-butyl phthalate. At this concentration of phthalate, there was no effect on cell proliferation, membrane integrity, or induction of apoptosis with the undifferentiated HUC-SCs. The HUC-SCs were then induced to differentiate in the presence of 10 nM DBP. Cells were collected after 20, 24, 28, 32, and 48 hrs of culture and analyzed as described above. Comparison of control vs phthalate treated cell extracts showed dramatic differences in protein expression. The differentially expressed proteins are being analyzed using matrix-assisted laser desorption/ionization time-of-flight mass spectroscopy (MALDI-TOF MS). The differentially expressed proteins may have potential as biomarkers for evaluating the extent of DBP exposure. Funded in part by a grant from CSUPERB.

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Uptake of metals by plants is often evaluated as part of baseline risk assessments, either in the form of ingestion of homegrown produce by humans or ingestion of plant material by omnivorous and herbivorous wildlife species. Often this pathway is evaluated by modeling the uptake of metals from measured concentrations in soil to aboveground and/or belowground produce. Available models for uptake in plants generally rely on the use of published or calculated biouptake factors, which introduces an added layer of uncertainty into the risk assessment process. At a former smelter facility in Oklahoma, it was observed that blackberry bushes were growing in piles of smelter waste material, namely slag. Since local residents were known to pick blackberries from these bushes, a biouptake study was conducted to evaluate metals concentrations in blackberry bushes. To provide data for addressing multiple exposure scenarios, samples were collected of roots, leaves, berries, and adjacent soil for laboratory analysis. Two sets of samples were collected from each location/bush, with one set of samples being washed prior to analysis and one set of samples remaining unwashed. Off-site samples were also collected to serve as a background comparison. With this data set, multiple comparisons were completed including comparison of source concentrations in soil to different parts of the plant, comparison of washed to unwashed data, and comparison of site data to background. Finally, the measured concentrations in the plant tissue samples were compared to the results from modeling concentrations in soil to both roots and aboveground plant tissue. The results of these comparisons indicated differences in metals concentrations that could noticeably impact human and ecological exposure levels. This presentation summarizes the data comparisons and the resulting implications to human health and ecological risk assessment.
Soil Management Program - A University Perspective

Julie Hampel and Dan Blunk

Brownfield remediation is a process in which abandoned or underused commercial or industrial property, often with low levels of contamination, is cleaned-up so the site can be redeveloped. In the 1950s and 60s, the University of California purchased a number of formerly used defense sites (FUDS) for future campus development. While FUDS are not considered Brownfields, these sites often require remediation of contamination discovered during construction before development can be completed.

Construction activities at UC FUDS have uncovered evidence of previous storage or use of hazardous materials, unexploded ordinance, and hazardous waste disposal during military occupancy. Although the Department of Defense is responsible for environmental restoration of FUDS, the government’s investigation process remains in the initial stages. Consequently, the current property owner must assess subsurface conditions prior to soil excavation for new buildings or pay the price of construction delays and cost overruns.

In response to aggressive development plans at each of the ten UC campuses, the campus Environmental Managers identified a need for the creation and implementation of a Construction Soil Management Program to aid in the management of risk associated with the discovery of subsurface contamination during development activities. The UC Soil Management Program, utilized during development planning stages, is inclusive of local requirements and acts as an insurance program for identifying potential project delays. This presentation describes two approaches to soils management (FUDS vs. non-FUDS): the up-front costs, an assessment of benefits and risk reduction, and the net impact on development projects meeting budget and schedule targets.

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Presenting Author: Dan Blunk
Oral Bioavailability and Dermal Absorption of PAHs in Soil: State of the Science and Applications to Risk Assessment

Michael Ruby, Yvette Lowney, Steve Roberts, John Kissel, Annette Bunge and Priscilla Tomlinson

This presentation will discuss the state of the science regarding the oral bioavailability and dermal absorption of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in soil. Direct contact exposures to chemicals in soil can occur by way of the oral, dermal, and inhalation pathways. However, human exposures from direct contact to cPAHs in soil are dominated by the oral and dermal exposure routes because exposure from inhalation of PAH-bearing soil particulates is generally negligible.

The discussion will review the in vivo studies conducted to date to measure the relative bioavailability of cPAHs from soil, the development and application of in vitro tests for evaluation of cPAH bioaccessibility, and the in vivo and in vitro studies conducted to assess dermal absorption of benzo(a)pyrene (BaP) from soil. Preliminary results from a research program to develop a robust in vivomodel for measuring the relative oral bioavailability of cPAHs, and an in vitro study of dermal BaP absorption, will be presented. The implications of these data for human health risk assessment will be discussed, along with the relative importance of oral and dermal absorption and their potential impacts on soil cleanup goals. Finally, upcoming changes in the regulatory toxicology of cPAHs, such as the pending toxicity reassessment for BaP, EPA’s proposed new relative potency factors, and the potential for a dermal cancer slope factor will be discussed, along with the possible implications of these changes on human health risk assessment.

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Estimating Soil and Dust Ingestion through the Blood/Soil/Dust Lead Relationship at the Bunker Hill Mining and Metallurgical Complex Superfund Site in Idaho

Marc Stifelman, Ian Von Lindern, Susan Spalinger, Mara Thorhaug and Lindsay Stanek

Soil and dust ingestion rates are an important parameter in the U.S. Environmental Protection Agency’s (USEPA) Integrated Exposure Uptake Biokinetics (IEUBK) Model for lead. Cleanup decisions at sites are often made on the basis of risk; errors in soil ingestion are proportional to errors in cleanup levels. Current estimates of soil ingestion rates are based on limited data (USEPA, 2009). There is consensus that uncertainty in soil ingestion rates is high and confidence in the supporting studies is low (Batelle, 2005; USEPA, 2008a; USEPA, 2009; Doyle et al., 2010).

The objective of this study is to measure the lead bioavailability of archived soil and dust samples from the Bunker Hill Mining and Metallurgical Complex Superfund Site (BHSS) and then estimate soil and dust ingestion rates. The information obtained from this work may reduce uncertainty in current estimates of soil and dust ingestion rates. The BHSS is a large mining and smelting area in northern Idaho with a representative data set of pediatric blood lead levels corresponding to house dust and soil lead levels. A subset of archived BHSS soil and house dust samples was analyzed for lead bioavailability in January 2013. These data will be combined with the historic data set to calculate separate ingestion rates for soil and house dust and quantifying partitions of residential soil, community soil, and house dust. Fit of predicted and observed blood lead levels will be used to evaluate the accuracy of estimated ingestion rates.

Current IEUBK soil/dust ingestion rates average 100 mg/day, and preliminary results of this study indicate total soil/dust ingestion rates near 60 mg/day. Preliminary estimates of absolute bioavailability are 33% soil and 28% dust. The preliminary results indicate higher bioavailabilities and lower ingestion rates than previously assumed at the BHSS and furthermore, indicate lower soil/dust ingestion rates than currently used.

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A Review of USEPA’s New RSLs for Total Petroleum Hydrocarbons

Usha Vedagiri and Kanan Patel-Coleman

In May 2013, for the first time, the USEPA’s on-line Regional Screening Level (RSL) calculator included a method for developing RSLs for TPH chemicals. The RSLs are screening levels that are widely used on a nation-wide basis to assess whether further action is needed to address environmental contamination in various media at a given site. The USEPA calculator generates RSLs for three aliphatic and three aromatic TPH fractions corresponding to high, medium and low carbon ranges. The USEPA method is based on a hybrid approach that uses both individual constituents of TPH as well as surrogate chemicals to represent the toxicity of aliphatic and aromatic fractions (USEPA 2009). Although fraction identification is similar to approaches used by others (e.g., Massachusetts, TPH Criteria Working Group), the USEPA approach includes some modifications in establishing the toxicity criteria and in risk characterization. It considers both cancer and non-cancer endpoints and can be used to develop screening-level estimates of cancer risks and hazard indices for petroleum hydrocarbon mixtures. This presentation provides a review of USEPA’s assumptions and methodology and compares it to some commonly used screening levels for evaluating human health risks for TPH. Example data will be used to illustrate how the new RSLs may affect decision-making at a site.

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Presenting Author: Usha Vedagiri
Recent Trends and Prevention for a Significant Occupational Hazard for Scientists and Engineers and Other Field Workers: Coccidioidomycosis: (Valley Fever)

James Jacobs

Increasingly, field workers in arid regions of the southwestern United States are at risk to environmental exposure to a dangerous fungal pathogen. When soil containing the fungus Coccidioides immitis is disturbed by anthropogenic activities, or natural causes such as wind, and earthquakes, microscopic fungal spores or arthroconidia (about 3 to 5 µm in size) can become airborne and lodged in the lungs of unsuspecting workers. Those who disturb soils in endemic areas by digging, drilling, trenching, and even driving vehicles may include geologists, archaeologists, engineers, wild land fire fighters, military personnel, construction staff for road building and excavation, and workers in the agricultural, mining, quarrying, and oil and gas industries. The environmental factors for the fungus growth are well understood and documented. The Centers for Disease Control and Prevention reported Coccidioidomycosis (Valley Fever) cases in Arizona, California, Nevada, New Mexico and Utah from 1998 to 2011 increased almost ten-fold, although some case reporting variations exist due to the laboratory procedures used or documentation methods. Symptoms can include influenza-like illness such as cough, fever, chest pain, headache, muscle ache, rash and general fatigue, but some victims develop more severe or chronic pulmonary disease. The disease can be costly and debilitating, with nearly 75% of patients missing work or school due to their symptoms and 40% requiring hospitalization. The talk will focus on 1) the life cycle of the dimorphic soil-living fungus, 2) the saprophytic phase in soil to the invasive phase in entering the host, 3) the symptoms of the disease, 4) the prevention strategies to protect field employees to use engineering and workplace controls, administrative controls, dust and spore reduction respiratory protection, aggressive dust control and active training of supervisors and field workers and 5) medical programs to monitor workers, recognize the symptoms and provide prompt and appropriate medical treatment.

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Presenting Author: James Jacobs
TBA: TRANSPORT, REMEDIATION AND SITE CLOSURE

Tert-butyl Alcohol (TBA) 101: History, Properties, and Toxicity
Katharine P. North and Renae Magaw, Chevron Energy Technology Company, San Ramon, CA

Microbial Isobutane Oxidation as a Potential Source of TBA in Hydrocarbon-Impacted Environments
Michael Hyman, North Carolina State University, Raleigh, NC

California Underground Storage Tank Low Threat Closure Policy (2012) and Tertiary butyl Alcohol (TBA) Factor: Case Study in Los Angeles, California
Yue Rong, CA RWQCB, Los Angeles Region, Los Angeles, CA

Understanding Treatment Mechanisms for MTBE and TBA

Low-Threat Closure Criteria for TBA
Tert-butyl Alcohol (TBA) 101: History, Properties, and Toxicity

Katharine P. North and Renae Magaw

Tert-butyl alcohol (TBA) contamination has been found at service stations, refineries, terminals, and other sites. In order to facilitate an understanding of the conceptual model of TBA impacts at these sites, an introduction to TBA history, physical and chemical properties, and toxicity will be presented. The presence of TBA at contaminated sites is most often thought to be associated with oxygenated fuel, but it can be derived from other sources and is still used today in industrial processes. TBA is a daughter product of methyl tert-butyl ether (MTBE). A timeline of MTBE and TBA use in reformulated gasoline can be difficult to determine but can help narrow the possibilities of when and where a release occurred, potentially providing a better understanding of the source. The physical and chemical properties of TBA suggest that it is more recalcitrant than MTBE and that it has the potential to form longer dissolved plumes, but this is not borne out by nation-wide plume studies. The results of those plume studies have been corroborated by a recent analysis of records from California’s GeoTracker database. The current understanding of TBA toxicity and implications for risk assessment and risk-based decision at contaminated sites will also be discussed.

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Microbial Isobutane Oxidation as a Potential Source of TBA in Hydrocarbon-Impacted Environments

Michael Hyman

The presence of tertiary butyl alcohol (TBA) in ground water is most commonly associated with co-contamination with ether fuel oxygenates such as methyl tertiary butyl ether (MTBE). However, isobutane, another common component of both gasoline and natural gas, potentially represent another source of TBA in diverse hydrocarbon-impacted environments. Our recent studies have demonstrated that both microbial metabolism and cometabolism of isobutane can result in stable production of TBA and that TBA production is a variable but apparently universal aspect of this process. Our studies have also established this isobutane-dependent TBA production is maximized under the oxygen-limited conditions often found in hydrocarbon-impacted environments. This presentation will summarize our recent research findings and will provide an overview of the types of environment that might be expected to support microbial production of TBA from isobutane. The presentation will also discuss isotope-based analyses that can potentially be used to discriminate the sources of TBA in these environments.

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Presenting Author: Michael Hyman
California Underground Storage Tank Low Threat Closure Policy (2012) and Tertiary butyl alcohol (TBA) Factor: Case Study in Los Angeles, California

Yue Rong

In 2012, the California State Water Resources Control Board adopted “Low-Threat Underground Storage Tank Case Closure Policy” which establishes statewide case closure criteria for leaking underground storage tank (UST) sites that pose a low threat to human health and the environment.

(http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2012/rs2012_0016atta.pdf)

The Policy provides some numerical criteria as UST case closure standard. The presentation will discuss the implementation of this Policy in Los Angeles Region.

However, while the Policy specifies closure criteria based on the gasoline oxygenate methyl tertiary butyl ether (MTBE) concentration, it does not address tertiary butyl alcohol (TBA), a popular groundwater contaminant. No Maximum Contaminant Level has been promulgated for TBA, and many states have not set specific cleanup goals for TBA in groundwater.

TBA is a metabolic byproduct of the degradation of MTBE. The degradation of MTBE and TBA may control plume migration at many petroleum release sites. As TBA degradation is typically slower than MTBE degradation under anaerobic conditions, however, it can extend the duration of both remediation and monitoring programs and delay site closure. The omission of TBA in the Policy may not mean TBA is not a deciding factor to consider for site closure. Since TBA is not specifically addressed in the Policy, additional attention and discussion of TBA is warranted. This presentation will discuss some case studies in Los Angeles Region, where TBA concentration distribution, degradation, and remediation may affect decision making on case closure.

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Presenting Author: Yue Rong
Understanding Treatment Mechanisms for MTBE and TBA

Jeff Mcdonough, Jeff Burdick and Leigh Neary

Methyl tert-butyl ether (MTBE) is a highly soluble environmental contaminant associated with uncontrolled releases from underground gasoline storage tanks. MTBE groundwater plumes are typically mobile and may pose a threat to downgradient receptors. Conventional remedial technologies that rely on physical extraction of MTBE have limited effectiveness, and may result in prolonged and costly remediation efforts.

Monitored natural attenuation (MNA) and engineered oxidation of MTBE through biological or chemical mechanisms present innovative alternatives to more costly physical removal strategies. Bench and field scale evidence for natural and engineered oxidation of MTBE is widespread throughout the literature. The oxidation of MTBE (C₅H₁₂O) can ultimately result in the mineralization of carbon to carbon dioxide (CO₂); however, the incomplete oxidation intermediary tertiary butyl alcohol (TBA – C₄H₁₀O) can be an indication of stalled MTBE oxidation. The increase and subsequent decrease in TBA in a natural setting can be an indication of intrinsic attenuation mechanisms supporting a low-cost MNA remedy. In an engineered system, the use of weak oxidants for remediation may be prone to TBA generation. Two examples of weaker oxidation potential are ambient activated persulfate and sulfate mediated anaerobic biological oxidation systems. As TBA is a regulated environmental contaminant, the selected remedial alternative for MTBE must be designed with a thorough understanding of the fate and transport of contaminants at the subject site. Intrinsic MTBE oxidation from numerous sites and treatability studies conducted at the bench scale will be presented to showcase the importance of proper oxidation design in limiting the generation of TBA as a result of insufficient oxidation potential.

In this presentation, a systematic understanding of the geochemistry and hydrogeology at MTBE/TBA impacted sites provide a technically defensible rationale for selected oxidation strategies. Case studies are presented and discussed for natural attenuation, aerobic bioremediation through bio-sparging and bioventing, and chemical oxidation through iron and alkaline activated sodium persulfate.

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Presenting Author: Leigh Neary
Low-Threat Closure Criteria for TBA

Eric Nichols and Jennifer Nyman

Tertiary butyl alcohol (TBA) commonly occurs at gasoline release sites as a metabolic by-product of the degradation of the gasoline oxygenate methyl tertiary butyl ether (MTBE). The degradation of MTBE and TBA may control plume extent at many petroleum release sites. While criteria for site closure are relatively well-established for MTBE, closure criteria are often unclear for TBA in groundwater. No Federal Maximum Contaminant Level (MCL) has been promulgated for TBA, and many states have not set specific clean up goals for TBA in groundwater. In 2012, the California State Water Resources Control Board adopted the Low-Threat Underground Storage Tank (UST) Case Closure Policy, which establishes statewide case closure criteria for UST sites that pose a low threat to human health and the environment. While the Low-Threat UST Closure Policy specifies closure criteria based on MTBE concentration and distance to receptors, it does not address TBA.

Multiple retrospective studies of long-term monitoring data at petroleum release sites have demonstrated similar behavior of MTBE and TBA in groundwater. Observed plume lengths and attenuation rates have been shown to be similar for MTBE and TBA, and the presence and relative concentration of MTBE and TBA with respect to variable geochemical conditions (e.g., oxidation-reduction potential) have been shown to be similar. These observations suggest low-threat closure criteria for TBA that are similar to, and potentially based on, MTBE closure criteria are technically justified.

This presentation will review the current status of closure criteria for TBA at the state level throughout the country and in California specifically. Alternate closure criteria for TBA, with supporting technical bases, will be proposed, and recommendations will be made for guidance and policies for closure of sites with TBA as a constituent of concern in groundwater.

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TECHNOLOGY ADVANCES IN REMEDIATION SCIENCE

A Multivariate Diagnostic Strategy to Examine Product Performance Claims
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Biogeochemical Reductive Dehalogenation and Metals Stabilization (BiRDS) - a New Option for Permeable Reactive Barrier Based Treatment of Groundwater
James Studer, InfraSUR, Albuquerque, NM

Automated Groundwater Monitoring for Metal Ions, Radiologicals and Volatile Hydrocarbons
Scott Burge, Burge Environmental, Tempe, AZ

Innovative Process that Detects Flow & Transport Mechanisms Invisible to Monitoring Wells
Todd Halihan, Oklahoma State University, Stillwater, OK; Stuart McDonald, Aestus, Loveland, CO; Mark Kluger, Dajak, Inc., Wilmington, DE

The QuantArray – the State of the Art in Environmental Microbial Diagnostics
Dora Ogles, Anita Biernacki, Brett Baldwin, and Kate Clark, Microbial Insights, Knoxville, TN

Advances in High Resolution Site Assessment
John Sohl, Columbia Technologies, Baltimore, MD

Novel Applications of Compound Specific Isotope Analysis (CSIA)
Robert Pirkle and Patrick McLoughlin, Microseeps a Division of Pace Analytical, Pittsburgh, PA; Matt Burns, WSP Environment and Energy, Woburn, MA
A unique investigation of an electron donor was made at a site in New Jersey. Usually it is difficult to evaluate reagent-based remediation as thoroughly as desired. Typically, after application there is often a lack of proper understanding as to where materials reside, migrate and perform in proper detail and our objective in this study was to address these issues. A 50 foot permeable reactive barrier (PRB) was installed using a carbon and iron emulsion to address a DNAPL source. The site contamination was examined and product application tracked with MIPS and LIF respectively. A series of 18 monitoring wells were installed to evaluate contaminant mass flux and standard physical and geochemical parameters. Data was automatically processed and transmitted to a Cloud-based Internet configuration. The 2D and 3D distributions of mobile mass were automatically displayed and cumulative mass flux reported. Environmental molecular diagnostics were also employed with standard MBTs and with novel microarrays. CSIA provided assessment of degradation. This integrated approach utilizing high resolution technologies resulted in a better understanding of both the contaminant and reagent distribution to optimize the remedial action solutions. Real-time geochemical data over time indicated a significant and sustained decrease of ORP following injection. MBTs confirmed the involvement of degrading microorganisms in the process on both individual and metagenomic bases. CSIA confirmed that degradation mechanisms caused contaminant loss. The assessment of contaminants were made using traditional analytical methods coupled with calculation of mass flux - the latter being very expressive at a "whole systems" level. The data will guide future vertical injection intervals and spacing that will generate major cost-savings. In essence, the use of multiple diagnostic tools to understand the performance of a reagent was fruitful and will help optimize full-scale treatment. All the participants in this study donated their resources to collectively demonstrate a new standard in verifying product performance.

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Presenter: Stephen Koenigsberg
Biogeochemical Reductive Dehalogenation and Metals Stabilization (BiRDS) - a New Option for Permeable Reactive Barrier Based Treatment of Groundwater

James E. Studer

Groundwater impact by halogenated compounds and/or heavy metals and metalloids (e.g., PCE, TCE, PCP, EDB, chromium, cadmium, arsenic) is a common occurrence across the industrialized regions of the world. Common treatment technology options for removal of these types of constituents from groundwater include groundwater extraction, ex-situ treatment and various in-situ treatment approaches. In-situ approaches are gaining in popularity and include air sparging, vacuum extraction, chemical oxidation, biostimulation including bio-augmentation, abiotic destruction by zero valent iron, chemical/physical stabilization and hybrid processes such as zero valent iron enhanced by biotic approaches. Interest in biogeochemical treatment, a new approach combining biological and abiotic processes, has been accelerating with the development of the patented BiRDS process. BiRDS (Biogeochemical Reductive Dehalogenation and Metals Stabilization) is aimed at generating, in-situ, amorphous and crystalline forms of iron sulfide (generally referred to as Fe₅S₉). Iron sulfide is capable of dehalogenating organics and removing metals and metalloids from solution via mineral incorporation and/or enhanced adsorption. The Fe₅S₉ reactive zone can be created rapidly, in just a few weeks essentially converting the mineral aquifer matrix itself into a reactive material. Once formed, iron sulfides can treat passing groundwater over a relatively long period of time (permeable reactive barrier). The technique can be applied by direct injection or trenching techniques using inexpensive non-toxic reactants which are readily available in either liquid or solid form.

The discriminating benefits of BiRDS include: 1) rapid degradation and stabilization of a wide range of halogenated compounds and inorganic species; 2) little or no production of undesirable transformation products cis-1, 2 DCE and vinyl chloride from PCE and TCE (and therefore avoidance of accumulation of these products); 3) reduced conversion of applied carbon based electron donor to methane; 4) highly robust process that can be implemented using low-cost treatment materials and 5) trench-based or direct injection construction techniques. Field demonstration of BiRDS has occurred at a variety of sites since 2004 and this biogeochemical technology is currently being tested and implemented at commercial scale as an economic effective alternative to other methods.

This presentation describes the salient features and benefits of the BiRDS technology. A case study involving the side-by-side demonstration of biological dehalogenation and BiRDS will be presented to illustrate the differences (and similarities) between the technologies. Information on on-going commercial applications will be presented as well.

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Presenting Author: James Studer
Automated Groundwater Monitoring for Metal Ions, Radiologicals and Volatile Hydrocarbons

Scott R. Burge

An automated groundwater monitoring system was developed for the field deployment of several types of sensors to determine the migration and natural attenuation of contaminants in groundwater. The groundwater monitoring system is capable of monitoring four to eight wells using a variety of commercially available water quality sensors including water level, pH, conductivity, ORP, dissolved oxygen, and ion-specific electrodes. Additionally, sensors have been developed for chromium(VI), trichloroethene, uranium, technetium-99, strontium-90, and volatile hydrocarbons. The system supports several types of water sampling techniques including peristaltic and centrifugal pumps. The system is completely automated and can be deployed in remote locations using solar and/or wind turbine power. The automated system is capable of performing calibration and/or quality control checks for all the water quality and chemical sensors using standards deployed with the monitoring system.

The data from the system can be transmitted by radio telemetry or cellular communications (via the web) to remote users. Data transmitted to the web has the capability being interfaced directly into groundwater contaminant distribution and mass flux visualization programs. Therefore, the final analytical results of the monitoring system are translated into easily understandable graphics to support the remedial action, or site management. This paper presents data from monitoring programs of three locations at the Hanford Site in Washington where the system was used to monitor uranium, hexavalent chromium, and technetium-99. Additionally, laboratory studies will be presented of a unified groundwater and soil-gas monitoring system for volatile hydrocarbons.

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Presenting Author: Scott R. Burge
Innovative Process that Detects Flow & Transport Mechanisms Invisible to Monitoring Wells

Todd Halihan, Stuart McDonald, and Mark Kluger

Monitoring wells are one of the most relied upon sources of data during site characterization work to elucidate flow and transport mechanisms on sites worldwide. Unfortunately, the reliance on this one dimensional data source leaves significant uncertainty in conceptual site models (CSMs). The GeoTrax Survey™ process, involving a propriety form of electrical resistivity imaging (ERI) designed specifically for the environmental industry, has detected many subsurface features of interest that are difficult or impossible to discern with monitoring wells alone.

Continuous two dimensional (2-D) ERI subsurface images allow relatively small features to be observed that would normally be missed by common well placement approaches. This includes preferential channels/flowpaths and/or discrete ganglia/blobs of non-aqueous phase liquids (NAPLs). This approach also detects vertical flow features (e.g. vertical fractures and substrate injection features) that are commonly missed or are uninterpretable using only vertical 1-D monitoring well data. This method can also illustrate vadose zone processes that are missed by monitoring wells designed to gather phreatic zone data. Finally, this tool provides strong data on site biogeochemical zonation that is difficult to discern using well data.

The strengths and weaknesses of integrating ERI data with monitoring well and biogeochemical data are discussed. The current and future research using this approach is presented.

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Quantitative polymerase chain reaction (qPCR) may be the most commonly applied environmental molecular diagnostic (EMD) with quantification of *Dehalococcoides mycartyi* now an indispensable component of assessment, remedy selection, and performance monitoring at chlorinated ethene sites. Likewise, qPCR quantification of oxygenase genes (e.g. toluene monooxygenases) and benzylsuccinate synthase (*bssA*) has long been employed to assess BTEX biodegradation at petroleum impacted sites. However, petroleum products are complex mixtures of aliphatic, aromatic, and cyclic compounds. Moreover, even for a class of related contaminants like BTEX, biodegradation can proceed by a multitude of different pathways. Similarly, *Dehalococcoides mycartyi* are not the only bacteria of interest and reductive dechlorination is not the only biodegradation pathway at chlorinated solvent sites. Thus, while still providing valuable information, comprehensive assessment of biodegradation potential with standard qPCR can be difficult due to the sheer number of critical microorganisms, functional genes, and biological processes. With simultaneous quantification of a broad spectrum of functional gene targets in a single platform, QuantArrays address this issue and provide more comprehensive yet cost-effective assessment of biodegradation potential. For chlorinated solvent sites, QuantArray analysis includes simultaneous quantification of: (1) six genera of organohalide-respiring bacteria, (2) reductase genes responsible for dechlorination of vinyl chloride, 1,2-dichloropropane, and chloroform, (3) oxygenase genes encoding enzymes capable of co-oxidation of chlorinated ethenes, and (4) functional genes for competing electron accepting processes including sulfate reduction. For assessment at petroleum hydrocarbon sites, the QuantArray includes assays not only for the well characterized aerobic pathways but also more divergent families of oxygenase genes and just as importantly a suite of functional genes involved in anaerobic biodegradation: (1) benzyl coenzymeA reductase genes (*bcrA*), (2) fumarate-adding enzymes (*bssA*, *nmsA*, and *assA*) for anaerobic biodegradation of toluene, methyl-naphthalene, and alkanes, and (3) the recently described benzene (*abcA*) and naphthalene (*ancA*) carboxylase genes. The presentation will emphasize case studies in which QuantArrays were used along with traditional groundwater monitoring to evaluate MNA, enhanced aerobic bioremediation and enhanced anaerobic bioremediation at petroleum hydrocarbon and chlorinated solvent sites.
Advances in High Resolution Site Assessment

John H. Sohl

One of the most critical steps in minimizing risk, reducing costs, and successfully and permanently closing impacted real estate with confidence is adequate site assessment and characterization. This includes a thorough understanding of the geochemistry, geology, hydrogeology, and microbiology. Historically, the failure to obtain sufficient representative information has been proven to be the largest cost driver in tackling the large, highly variable statistical challenge at complex sites. The result has often been a challenging and expensive approach to characterization and remediation with mixed success.

During this presentation, John Sohl will present the most recent developments in high resolution site characterization (HRSC) that help address these challenges and improve the confidence of decision makers. John will provide case examples illustrating the use of remediation focused direct sensing tools such as Laser Induced Fluorescence (LIF), Membrane Interface Probe (MIP), and the Hydraulic Profiling Tool (HPT), onsite analyses, and real time data management tools to support decision makers in achieving future project plans. These technologies can be used both as an upfront investigation tool as well as a planning tool for remediation.

The new generations of tools enable site decision makers to understand the details of soil permeability leading to better understand NAPL storage, transport, mobility, and recoverability. Combining lines of high resolution evidence enables decision makers to more cost effectively develop sampling and remediation plans and implement a remediation performance strategy.

Experience indicates that high resolution site characterization approaches are able to provide a 3-10x return on cleanup and closure – cost-effectively remediating these sites while reducing the mass distribution of mobile contaminants at the properties. This presentation will discuss project examples including NAPL distribution assumptions and how proper data on NAPL and soil permeability can be used to develop an effective conceptual site model with advanced real-time characterization tools.

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Presenting Author: John H. Sohl
Compound Specific Isotope Analysis (CSIA) is a powerful new tool for in-situ degradation and environmental forensic applications. The observation of isotopic fractionation is unequivocal proof of contaminant degradation. The ability to distinguish degradation and dilution is extremely important in remedial technologies like in-situ chemical oxidation (ISCO) where significant amounts of fluids are injected into the groundwater. This presentation will include a brief discussion of the fundamentals of CSIA and describe its use in the implementation and management of remediation using in-situ chemical oxidation.

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Presenting Author: Robert J. Pirkle
VAPOUR INTRUSION

Comparing Conventional and Innovative Vapor Intrusion Assessment Methods to Reduce Costs and Improve Data Quality and Spatial Resolution
Todd McAlary, Bill Wertz, Hester Groenevelt, and Matt Vanderkooy, Geosyntec Consultants, Guelph, ON, Canada; Ryan Smith and Robert Ettinger, Geosyntec Consultants, Santa Barbara, CA; Chuck Ramsey, EnviroStat, Inc., Fort Collins, CO

Compound-Specific Stable Isotope Analysis to Distinguish Vapor Intrusion from Indoor Sources of VOCs
Lila Beckley, GSI Environmental, Inc., Austin, TX; Tomasz Kuder and R. Paul Philp, University of Oklahoma, Norman, OK; Thomas McHugh, GSI Environmental, Inc., Houston, TX

Operations and Maintenance (O&M) Monitoring of Vapor Intrusion Mitigation Systems
Efrem Neuwirth, Chawn Jeng, and William Bosan, California EPA, DTSC, Cypress, CA

Diverse Building Envelope Types and their Importance for Vapor Intrusion
Chris Lutes, ARCADIS U.S., Inc., Durham, NC; Rachel Saari, Milwaukee, WI; Margaret Bartee, ARCADIS, Cranbury, NJ; Eric Epple, ARCADIS, Seattle WA; Brian Cosky, ARCADIS, Indianapolis, IN

Simulated Distributions of Indoor Air Concentrations for Vapor Intrusion Sampling Strategies – Confirmation using High-Resolution Data
John Lowe, CH2M HILL, Spokane, WA; Loren Lund, CH2M HILL, Shelley, ID
Comparing Conventional and Innovative Vapor Intrusion Assessment Methods to Reduce Costs and Improve Data Quality and Spatial Resolution

Todd Mcalary, Bill Wertz, Hester Groenevelt, Matt Vanderkooy, Ryan Smith, Robert Ettinger and Chuck Ramsey

Current guidance documents typically recommend collecting sub-slab samples to characterize the concentrations of VOCs below a building, which is expensive and time consuming for large buildings. Multi-Incremental Sampling® (MIS) and high volume sampling (HVS) methods are two alternative approaches for assessment. A demonstrations/validation study was performed for the Air Force to compare these methods with conventional Summa canister samples and analysis by EPA Method TO-15 at two slab on grade buildings at Vandenberg Air Force Base. The first building was large (50,700 ft²) with measured sub-slab TCE concentrations ranging from non-detect to 14,000 ppbv. The second building was a medium-sized (11,200 ft²) former dry cleaner facility with sub-slab PCE concentrations ranging from non-detect to 180,000 ppbv.

The MIS approach was based on collecting composite samples from a grid of temporary sub-slab sampling points. MIS can include as many or more sub-slab sampling locations as conventional Summa canister sampling approaches, but because the compositing process reduces the number of samples submitted for analysis, the overall analysis cost is reduced.

HVS testing consists of extracting soil gas at a high flow rate (hundreds or thousands of liters per minute) for 30 to 60 minutes. The extracted soil gas is continuously monitored using portable instrumentation and periodically sampled via Summa canisters to infer vapor concentrations as a function of distance from the extraction point. Unlike conventional sampling, which only provides information about the concentration of VOCs at any given point in the sub-slab, the HVS test results provides information regarding the vapor distribution between and beyond sampling points. Pneumatic data collected during the HVS test can be used to account for dilution of the sub-slab vapors.

Results of the MIS and HVS methods will be compared to the conventional Summa/TO-15 method in terms of the information gained, ease of use, and cost.

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Presenting Author: Todd McAlary
Compound-Specific Stable Isotope Analysis to Distinguish Vapor Intrusion from Indoor Sources of VOCs

Lila Beckley, Tomasz Kuder, R. Paul Philp and Thomas McHugh

Sampling indoor air is the most direct way to evaluate exposure to volatile organic chemicals (VOCs) which may occur as a result of vapor intrusion (VI). Interpreting the results of indoor air samples, however, is often challenging because indoor sources such as consumer products often contribute to the contaminants found in indoor air. The challenge of correctly identifying buildings with VI impacts can be mitigated through use of compound-specific stable isotope analysis (CSIA).

Because the CSIA approach is not concentration-based, it offers an independent line of evidence to determine the source of VOCs. Many elements, such as carbon, occur as different isotope species, differing in the number of neutrons present in the nucleus. Isotopic ratios of a specific compound (e.g., the ratio of $^{13}$C/$^{12}$C in trichloroethylene) can vary because of differences in the source material, compound synthesis, or due to transformation in the environment. As a result, the isotopic signatures of subsurface sources such as contaminated groundwater are often distinct from the signatures of manufactured products.

Based on this distinction, we have developed an investigation protocol using CSIA to identify the primary source of VOCs in indoor air. The protocol, designed for use within the context of a larger VI investigation program, is applicable to buildings in which VOCs (e.g., trichloroethylene, tetrachloroethylene, and benzene) have been measured at levels approaching or exceeding regulatory screening levels. The protocol includes specific step-by-step sample collection, analysis, and data evaluation procedures. We have validated the protocol at several Department of Defense sites by conducting side-by-side investigations using CSIA and two other investigation methods: conventional and on-site GC/MS analysis. The presentation will include case studies illustrating how the CSIA approach was used to identify one building impacted by VI and others in which indoor sources were the primary sources of VOCs in indoor air.

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Presenting Author: Lila Beckley
Operations and Maintenance (O&M) Monitoring of Vapor Intrusion Mitigation Systems

Efrem Neuwirth, Chawn Y. Jeng and William Bosan

The DTSC Vapor Intrusion Mitigation Advisory (VIMA; Final Revision 1, October 2011) provides guidance on monitoring the effectiveness of vapor intrusion (VI) mitigation systems, which is a required part of the Operations and Maintenance (O&M) Plan. VI mitigation systems come in a variety of active and passive systems, and monitoring the effectiveness of these systems can vary depending upon the preferences of the building owners/occupants, and other site specific conditions such as whether the mitigation system is in place to address known VI circumstances, or to be preventive in the absence of established VI. However, the VIMA is not prescriptive regarding monitoring requirements for certain situations that may arise. Monitoring of VI mitigation systems can include pressure measurements for active systems, as well as soil gas between the source material and the building, soil gas immediately above and below a barrier, air in vent pipes, and indoor air for both active and passive systems. The monitoring to be performed should be sufficient to demonstrate that the exposure pathway between contaminated media and indoor air receptors is eliminated, or the indoor air concentrations are reduced to an acceptable level. Several case studies will be presented highlighting general guidelines and site-specific considerations in designing and implementing a monitoring plan.

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Presenting Author: Efrem Neuwirth
Diverse Building Envelope Types and Their Importance for Vapor Intrusion

Chris Lutes, Rachel Saari, Margaret Bartee, Eric Epple and Brian Cosky

The primary focus of vapor intrusion (VI) guidance has been on common US suburban housing styles. VI guidance has focused on three foundation types: slab on grade, crawl space, and basement. Most volatile organic compound VI guidance treats wall systems cursorily but presumes the most current, most common residential construction style: platform framed wood construction. However, much of the rich diversity of the nation (and world’s) housing stock has been overlooked. This talk will highlight less common building features that would have important implications for VI site assessment – substantially decreasing or increasing the attenuation. Improved understanding of these features will enhance our ability to explain variability in indoor air concentrations within neighborhoods, to identify “worst case” structures over large plumes, and to customize mitigation strategies.

Among the construction styles to be examined will be:
- “Walk out” basements
- Permanent wood foundations (basements)
- Split-level plans
- Hollow tile as a construction material
- Rammed earth, straw bale, adobe, and earth sheltered
- Mobile homes and their conversions and additions
- Pier foundations
- Raised slabs
- Commercial buildings converted to residential

Examples will be presented as photographs and cross sections. Information and references will be drawn from diverse fields including historical preservation, vernacular architecture, housing renovation, and building science. Suggestions will be provided for how these construction styles can be identified – emphasizing features that can be identified prior to building access through street level observations, aerial photography, or on-line resources (property tax and census).

We will discuss residential basement features that require evaluation when present such as historical cisterns, bomb shelters, and coal storage. The resistance of various wall systems to vertical gas transmission will be covered including balloon framing, timber framing and log construction. Important wall system features such as designed ventilation/drainage systems, hollow blocks and veneers will also be discussed.

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Simulated Distributions of Indoor Air Concentrations for Vapor Intrusion Sampling Strategies – Confirmation Using High-Resolution Data

John Lowe and Loren Lund

High-resolution vapor intrusion (VI) sampling data from research houses are being used to evaluate a recently-published simulation methodology that assesses the effectiveness of indoor air sampling strategies in assessing VI exposures. The simulation methodology is based on a first-order autoregressive process which generates simulated hourly time series of indoor air concentrations over the course of one year. This methodology allows the simulation of indoor air concentrations with varying degrees of temporal variability through selection of a geometric standard deviation along with simulation of differing levels of hourly autocorrelation. Bootstrapping methods are used to randomly select starting hours for the collection of air samples. Groups of hourly concentrations are then collected and averaged to produce simulated time-weighted average sample concentrations of varying durations – 24 hour, 168 hour (one week duration) and 336 hour (two week duration). Sampling statistics can be calculated and compared with known statistics drawn from the full time series. Application of the bootstrapping and averaging methods to the high-resolution data sets will provide statistics drawn from measured data which can then be compared with statistics from simulated data. Comparisons of the simulated time series with measured high-frequency sampling data from VI research houses are intended to provide confirmation and limited calibration of the simulation methodology, for the purpose of increasing its usability in assessing the effectiveness of VI sampling designs.

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Presenting Author: John Lowe
WATER REUSE - NOT JUST FOR GOLF COURSES ANYMORE

Recycled Water Policy: A Statewide Perspective
Shahla Dargahi Farahnak, State Water Resources Control Board, Sacramento, CA

Wastewater Recycling Using Microbial Fuel Cells
Orianna Bretschger, J. Craig Venter Institute, San Diego, CA

SURF’s Case (Studies) for Water Reuse at Remediation Sites
Carl Lenker, Gannett Fleming, Irvine, CA

Direct Potable Reuse: Taking Reuse to the Next Level
Fernando Paludi, West Basin Municipal Water District, Carson, CA

Potable Reuse Research for City of San Diego
Bill Pearce, City of San Diego, San Diego, CA

Drivers, Trends, and Expanding Opportunities for Water Recycling
Tim Thomure, HDR Engineering, Inc., Phoenix, AZ
Recycled Water Policy: A Statewide Perspective

Shahla Dargahi Farahnak

This presentation provides an overview of recycled water use and summarizes the state’s effort to promote increased use of recycled water while protecting public health and water quality. Because California is facing drought-related water supply shortfalls, recycled water has gained prominence as a valuable water resource. The 2009 California Water Plan identifies recycled water as a resource that can augment water supply with a potential volume of 1.8 to 2.3 million acre-feet per year (MAFY) by 2030. The Recycled Water Policy (Policy) was adopted by the State Water Resources Control Board (State Water Board) in 2009 and was amended in 2013. The Policy sets the goal to increase the use of recycled water over 2002 levels by at least 1 MAFY by 2020 and by at least 2 MAFY by 2030. The Policy mandates increased use, provides incentives for use, streamlines permitting, identifies constituents of emerging concern (CECs), establishes monitoring for CECs, and requires development of regional salt/nutrient management plans (SNMPs). As of January 2014, SNMPs have been developed for 47 percent by area of identified groundwater basins, including 91 percent of basins designated as priority basins.

Current efforts of the State Water Board for expanding recycled water use include collaboration with the California Department of Public Health (CDPH) to develop uniform water recycling criteria and to merge the Drinking Water Program with the State Water Board. The CDPH is developing uniform water recycling criteria for indirect potable reuse (groundwater recharge) and surface water augmentation, and is evaluating the feasibility of direct potable reuse. Consolidation of the Drinking Water Program with the State Water Board would streamline the recycled water permitting process, increase collaboration, and improve permit quality.

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Recycling Using Microbial Fuel Cells

Orianna Bretschger

Microbial fuel cells (MFCs) have long been researched for their use as energy recovery devices during wastewater treatment. However, commercial applications of MFC systems have been challenged by high material costs and low energy recovery efficiencies. While energy densities remain low for these systems, recent work has demonstrated a reduction in capital costs, low biomass production, odor reduction, and accelerated treatment rates relative to conventional anaerobic systems. To-date a small pilot scale (100 gallon) anaerobic MFC system is able to remove a majority of biological oxygen demand (BOD) and volatile suspended solids (VSS) from primary sludge and primary effluents. A maximum BOD removal rate of 1.09 kg-BOD/m$^3$/day was achieved for primary sludge samples when operating the system at ambient temperatures. While system improvements are still required, these results represent significant progress toward the practical development of MFCs for municipal wastewater treatment and suggest that MFC technology may contribute toward realizing energy efficient water recycling.

Acknowledgements: Funding for this project was provided by the California State PIER EISG program, NSF BBBE award 0933145, the Roddenberry Foundation, and the San Diego Foundation Blasker Science and Technology Award.

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Presenting Author: Orianna Bretschger
SURF's Case (Studies) for Water Reuse at Remediation Sites

Carl Lenker

The Sustainable Remediation Forum (SURF) promotes the use of sustainable practices during implementation of remedial action activities with the objective of balancing economic viability, conservation of natural resources and biodiversity, and the enhancement of the quality of life in surrounding communities. In 2012, SURF undertook an initiative to improve the sustainability of remedies by encouraging a greater focus on conservation and reuse of groundwater at cleanup sites. To that end, SURF produced a white paper in December 2013 titled “Conservation and Reuse of Groundwater at Remediation Sites.” This document considers the impediments to conservation and reuse, and also provides case study examples where reuse of treated groundwater from remediation sites was accomplished. The document also highlights examples of reuse from the municipal wastewater industry, focusing on situations where concerns similar to those associated with reuse of groundwater from remediation sites were successfully resolved. This presentation will include an informative overview of the document and highlight the noteworthy case studies where reuse of treated groundwater has been successful.

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Presenting Author: Carl Lenker
Direct Potable Reuse: Taking Reuse to the Next Level

Fernando Paludi

Recycled water as a local supply source has been instrumental in protecting Southern California from droughts over the past three decades. It is a cornerstone of a sustainable water future for the state. In fact, the state’s recycled water policy includes a goal of increasing the use of recycled water by at least one million acre-feet per year (afy) by 2020 and at least two million afy by 2030. Can we get there? The answer largely depends on how quickly Indirect Potable Reuse (IPR) can be expanded and whether Direct Potable Reuse (DPR) can be realized.

IPR has been pioneered in Southern California since the 1970s. IPR employs advanced treatment on wastewater to produce high purity water to be ultimately used as a potable supply after a minimum time in an environmental buffer. West Basin Municipal Water District (West Basin) has almost 20 years of experience injecting advanced treated recycled wastewater into the local groundwater aquifer in coastal Los Angeles County, from which cities and agencies pump into local retail systems for consumption.

With the success of IPR projects at West Basin and in Orange County, the concept of DPR has now been considered to accommodate communities without access to environmental buffers such as groundwater basins or surface reservoirs. DPR removes the need for an environmental buffer. Years of water quality data have demonstrated that this water supply source would be a reliable high quality supply.

Since the introduction of SB 918 in 2010 and the work of local water districts developing IPR projects, the water reuse community has developed a research program that will help bridge the gap from successful IPR to DPR. Research identified includes the need for improved online monitoring, engineered buffer design, and new approaches to public outreach.

WateReuse California in conjunction with WateReuse Foundation have developed a research "Road Map" that will assist the water community take the next step in this emerging field.

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The City of San Diego (City) imports approximately 85% of its water supply from outside the region. Over the past 10 years, the City has been investigating potable reuse as an option for increasing its local water supply reliability. In June 2011, the City began the operation and testing of a one million gallons per day demonstration scale Advanced Water Purification (AWP) Facility located at the North City Water Reclamation Plant (North City). Data generated from the demonstration project was used to support the City’s proposal for conditional regulatory approval and estimate the capital, operational and maintenance (O&M) costs of a potential full-scale project. The potential full-scale project would purify tertiary effluent from North City for indirect potable reuse via surface water augmentation at San Vicente Reservoir. Following completion of the demonstration testing, the City obtained conceptual regulatory approval for a full-scale project from the California Department of Public Health and Regional Water Board. The final project report was also unanimously adopted by the City Council. This presentation will discuss key findings from the demonstration testing, remaining technical challenges, and the City’s current research initiatives at the AWP Facility.

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Drivers, Trends, and Expanding Opportunities for Water Recycling

Tim Thomure

Markets for recycled water have evolved over the past few decades as technologies and drivers have changed. The industry’s focus has transitioned from meeting the challenges of “wastewater disposal” to the recognition that recycled water is a sustainable, resilient supply with numerous opportunities for beneficial use. Recycled water uses have expanded to keep pace with that changing focus. This presentation will provide a state-of-the-industry perspective on three main trends in recycled water: 1) Traditional reuse in non-traditional areas; 2) Industrial use for supply chain control; and 3) The current and very “Direct” conversations related to potable reuse.

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Presenting Author: Tim Thomure
POSTER PRESENTATIONS

(in alphabetical order by presenting author)
The Effect of an Induced Benzene Plume on Microbial Communities in a Groundwater Aquifer Mesocosm

Eferhire Aganbi, Arturo Aburto-Medina, Anne Fahy, Terry Mcgenity and Andy Ball

This study investigated the degradation of a benzene plume by indigenous microbial communities in sediments and groundwater from the SIReN (Site for Innovative Research in Natural Attenuation). A sandbox mesocosm system was inoculated with SIReN sediments/groundwater and spiked with benzene plume (starting concentration of 1000 mg l⁻¹). Benzene plume in the sandbox was degraded almost at the point of entry and was not transported across the sandbox. DGGE analysis of 16S rRNA gene (rDNA) allowed the detection of species closely related to Rhodoferax ferrireducens (95% similarity) and Dechloromonas aromatica RCB (99% similarity). Other organisms detected were closely related to the Betaproteobacteria isolate HTCC349 (96 – 97% similarity), various Methylophilus spp. (95 – 96% similarity) and Methylotherma mobilis strain JLW8 (96% similarity). These results demonstrated that benzene contamination had a profound impact on the community structure and composition of indigenous bacteria. Furthermore, the abundance of methylotrophic bacteria may be indicative of a more ‘active’ role in bioremediation than previously known.

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Assessment of Zeolite Minerals on Removal of Heavy Metals from Wastewater

Saud Al Oud

Zeolite minerals are very widespread in the world and in Kingdom of Saudi Arabia. They are present in the form of crystals formation with thermal water in the gaps and cracks of volcanic rocks. This research aims to study the efficient use of zeolite minerals on removing some heavy metals (lead, cadmium, copper and iron) form wastewater using different size and amount of zeolite minerals in a column experiment study was examined.

A laboratory sitting were conducted. First a patch study to examine adsorption and desorption of copper and lead was conducted. Second experiment was carry out to study the behavior of adsorption of heavy metals (lead, cadmium, copper, iron) in columns by adding zeolite mineral in a layer thickness of 1 cm below the column of washed sand depth of 20cm. Third experiment was performed to study the behavior of adsorption of heavy metals (lead, cadmium, copper, iron) in columns by adding zeolite mineral at different rate and mixed it with sand in a column experiment.

Results showed that the adsorption percent of copper onto the natural powdered or granulated zeolite was higher than adsorption of lead while the proportion of recovered lead was greater than the recovered copper in the desorption experiment. Estimates of removal efficiency of heavy elements indicated that the percent of copper and lead removal gradually decrease with the increase of the initial element concentration and the equilibrium concentration. Increasing initial metal ion concentration significantly increased the concentration of desorbed ions, indicating that adsorption sites were saturated at higher concentrations. In conclusion results revealed that homogenous mixing of the zeolite mineral with washed sand was more efficient in metal ions adsorption than as a layer. The affinity between zeolites and metal ions was in the order of Fe^{2+}>Cd^{2+}>Cu^{2+}>Pb^{2+}.

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Groundwater Quality and Its Suitability for Domestic and Agricultural Use: A Case Study Saq Aquifer of Northwestern Part of the Kingdom of Saudi Arabia

Nassir Al-Arifi

Assessment of suitability of groundwater for domestic and agricultural uses was carried out in Saq aquifer of Northwestern part of Saudi Arabia. The study area covers 375,000 km² and lies in the arid climate with low annual rainfall. In the study area groundwater is almost the major source for domestic and agricultural activity. A total of 295 samples of groundwater were collected from 295 water wells in the Saq aquifer areas. The water samples were analyzed for the parameters such as hydrogen ion concentration (pH), total dissolved solids (TDS) and electrical conductivity (EC), sodium (Na⁺), potassium (K⁺), magnesium (Mg²⁺), and calcium (Ca²⁺), bicarbonate (HCO₃⁻) chloride (Cl⁻), sulfate (SO₄²⁻), silicon dioxide (SiO₂), and nitrate (NO₃⁻). Suitability of groundwater for irrigation and domestic uses was evaluated based on salinity hazard, sodium carbonate, US salinity diagram, Wilcox’s diagram, Kelly’s ratio and permeability index. 8% sample classify as moderately hard type. The remaining 50% and 42% samples classify to 'hard' and 'very hard' water class. The ternary diagrams show Na⁺, Ca²⁺, mix cation type and Cl⁻, SO₄²⁻, mix-anion enriched trend. About 60% of the total samples have alkalis abundance and rests have more Ca+Mg concentrations than alkalis. Based on sodium percentage (Na%), 65% samples falls within excellent to permissible category of irrigation water use. About 12% and 10% samples are classified as permissible to doubtful and doubtful to unsuitable. However, about 13% of the water samples have high EC values making it unsuitable for irrigation use. Based on the residual Mg/Ca ratio, the groundwater samples can be classified as safe (< 1.5), moderate (1.5 to 3.0) and unsafe (>3) for irrigation. In the present study, 96% sample classifies to be in safe category and rest show moderate suitability for irrigation based on Mg hazard.

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Statistical Characterization of the Hydrochemical Data’s of Groundwater in Wadi AdDawasir Area, Saudi Arabia: A Probabilistic Assessment

Nassir Al-Arifi

A total of 283 samples of groundwater were collected for chemical analyses from 283 boreholes in the Wadi AdDawasir area, northwestern Saudi Arabia. In this study a total of 12 elements were considered namely: pH, EC, Eh, TDS, TH, Ca, Cl, HCO3, Mg, Na, NO3, and SO4. The goal and challenge for the statistical overview was to delineate chemical distributions in a complex, heterogeneous set of data spanning over a large geographic range. After declustering to create a uniform spatial sample distribution with 283 samples, histograms and quantile-quantile (Q-Q) plots were employed and used to delineate subpopulations that have coherent chemical affinities. Many locations show higher than the permissible values of pH, EC, HCO3 and Na. As a dominant constituents, the concentration of anion is in the order SO4>Cl>HCO3. Some of the analyzed parameters approach a normal distribution, as both their skewnesses and kurtoses reach close to “0”. The study revealed that, most of the metal pairs exhibit positive relations (except for Eh, EC, Mg, and NO3). The elements showing significantly higher positive correlation are: TDS with EC; TH and EC, TDS; Ca and EC, TDS, TH; Cl and EC, TDS, TH, Ca; Mg and EC; Na and EC, TDS, TH, Ca, Cl; NO3 and Mg; SO4 and EC, TDS, TH, Ca, Cl, Na. Taking both results of cluster tree and geochemical features of variables into consideration, the authors classify the elements into three categories, the first includes Na and SO4 where the relationship within the group are strong. The second group includes Mg, NO3, pH, HCO3, and Ca. This group has close relationship with group 1 demonstrate that, the increase in the concentration to some elements could be the same. Group 3 comprised TH, Cl, Eh, EC, and TDS.

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Trees and Their Applicability in Identifying Landfill Leachate Contamination of Subsurfaces, Shanghai, China

Gloria Appiah-Sefah, Huang Jingyu, Fan Xi Hui

Contamination of groundwater aquifers and soil by leaking landfill leachates is a major issue for environmentalists and the whole populace. China as part of its development have had to deal with this issue basically because of the increase in the use of various chemicals which are used in producing a wide range of products for many parts of the whole world. These are disposed off in landfills, released into leachates and sometimes end up in groundwater or soils through leakages. Excavation of soils, digging of groundwater wells and the use of other remote sensing methods such as resistivity surveys are often employed in identifying these contaminants especially volatile organics (VOC). However, these methods are expensive, require high level of expertise and also have the potential of reintroducing these VOCs into the environment. The objective of the study therefore was to examine the potential of using Cinnamomum camphora trees (1km away from the site) to identify groundwater and soil contamination from landfill leachates in Shanghai. Solid phase microextraction (SPME) and gas chromatograph mass spectrometer (GC/MS) were used for VOC extraction and analysis of tree cores samples respectively. From the results, alkenes, alkanes and aromatic hydrocarbons were the major classes of VOC that were in the subsurface and might have been from leachates leaked into the subsurface. The VOCs identified are those that are mostly used in the production of aerosol sprays, cosmetics, disinfectants, wood preservatives, paints among other common household products which also form higher proportion of wastes disposed of in the landfill. The study therefore shows that, the groundwater and soil may have been polluted with landfill leachates and suggests further research in the area to determine the extent of pollution of the subsurface to prevent future damages and harm to the environment.

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Proof of Concept Evaluation: Passive In-Situ Bioremediation of Chlorinated-Benzene Groundwater Contaminants Using Green Technology

I. Richard Schaffner and Kent Armstrong

Field Proof-of-Concept evaluation using injection and passive additive deployment. Performed to demonstrate anaerobic remediation of chlorinated-nonchlorinated-benzene groundwater contaminants. Performed as landfill closure program in compliance with state regulatory Remediation Order of Approval. Results of 7-month evaluation demonstrated > 90% decrease in site Contaminants-of-Concern (COC) 1,2- and 1,4-dichlorobenzene, chlorobenzene, and benzene.

Site former landfill with COC source mass within saturated mixed soil/waste. ‘Treatment Zone’ (TZ) targets smear zone/dissolved phase contaminants within/beneath suspected contaminant source. Additive selected (BioStryke® TPHENHANCED™) for ability to leverage existing site conditions, expedite mass desorption and contaminant biodegradation.

Deployment performed via 1) Passive Release Sock (PRS) into 2-inch monitoring well; and, 2) direct injection into two 8-inch wells; Area-of-Influence (AOI) < 3-feet and 18-feet, respectively. PRS units deployed one per 5-feet of saturated well screen, remain suspended and undisturbed, passively amending groundwater. PRS units contain 2 pounds additive, were replaced bi-weekly (11 times). Injected additive blended with water to achieve 525 mg/L, deploying 3,400 and 5,700 gallons of slurry, respectively.

Baseline-performance groundwater monitoring/sampling/analytical testing was performed prior to and throughout.

At the injection locations results of the 7-month Proof-of-Concept evaluation demonstrated:

- Order-of-Magnitude (OM) Decrease in Benzene to below the Site
- MCL (5 μg/L).
- Average gross %Reduction in Chlorobenzene of ≈ 90%.
- Average gross %Reduction in 1,2-Dichlorobenzene of ≈ 93%.
- Average gross %Reduction in 1,4-Dichlorobenzene of ≈ 96%.

The PRS location demonstrated significantly lower performance. There was little overall reduction in COC concentrations; however, a significant increase in contaminant bioavailability was observed, evidenced by a 4X increase in dissolved phase [Chlorobenzene] concentrations. This level quickly decreased to baseline; representing a 59% decrease from peak bioavailability. At both PRS and injection locations secondary evidence indicative and supportive of additive induced anaerobic biodegradation was observed to include: increased additive concentrations quickly followed by dramatic decreases in same, increases in bioavailability, significant decreases in COD levels, and slightly elevated pH levels.

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Presenting Author: Kent Armstrong
Implications for Water and Soil Contamination by Coal Fly Ash (FA) Disposal

Jerzy Bilski

Coal fly ash (FA) contains multiple toxic elements, predominantly heavy metals, and the disposal of FA may lead to leaching out of these elements and contaminate soils as well as surface water and groundwater. This contamination could lead to health, environmental and land-use problems. This study investigated the leaching of selected trace elements (Cs, Li, Be, Sr, Ba Ti, Zr, V, Cr, and Mo) from two coal FA (one from semi-bituminous coal and one from lignite), and from the soil used as control. Leachate fractions were collected at each ½ pore volume for a total of five pore volumes. Concentrations of mentioned above trace elements in the leachate have been measured in Mehlich3 (M3; 0.02 M glacial acetic acid + 0.25 M NO₃ + 0.015M NH₄ F + 0.013 M HNO₃ + 0.001 M EDTA) extracts using inductively coupled plasma (ICP) emission spectrophotometry. The differences between the results due to various FA sources, pore volume rates, and sample depth were evaluated using statistical analysis. The level of trace elements in the leachates was similar in two coal FA tested and predominately it was higher in the leachates from FA than from the soil control. The associations between pore volumes of leachates collected and the presence of trace elements in the leachate was not manifested. Elevated concentrations of Li, Sr, Ba and V in the leachates may cause some environmental health concerns and require further investigations.

Our study indicates that detailed evaluation of trace elements leaching from FA should be performed before FA utilization, especially as a component of plant growth media.

Support: North Dakota INBRE Grant Number P20 RR016741

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Two Stage Physiologically Based Extraction Test for Aluminum, Cobalt, Manganese and Vanadium in Soil

Mark Bowland, Mark Jones, Cindy Schreier, Ranajit Sahu and Lee Farris

Typically for environmental risk assessments, relative oral bioavailability of most chemicals of potential concern is conservatively assumed to be 100 percent, an assumption necessitated by the fact that data to support alternatives are often not available. In vitro physiologically based extraction tests (PBETs) have been designed to simulate the human gastrointestinal tract to assess the mobilization of compounds from soil during the digestion process, providing reasonable approximations of bioaccessibility. The objective of the present study was to provide site-specific information to evaluate the relative oral bioavailability of selected metals from site soils. Much of the research effort around bioavailability and bioaccessibility testing has centered on arsenic and lead. This study was implemented specifically for in vitro bioaccessibility testing of four metals: aluminum, cobalt, manganese, and vanadium. These metals are generally the greatest contributors to the risk estimates for the subject site. In addition, arsenic was also included in the study to evaluate the consistency with other similar studies. While it is recognized that there may be a paucity of in vivo validation data, there are several studies to indicate the applicability of PBET techniques for these four metals. Oral bioavailability varies with oxidation state, chemical form, and minerology. The four metals in the study are all cationic, with oxidation states typically present in soils similar to either arsenic or lead. The results of the PBET study indicate that the study data were of good quality, with consistent bioaccessibility values between samples for each of the four metals. Results of the PBET test were incorporated into the risk assessment conducted for the site. An evaluation of the effects of the bioaccessibility values on the risk estimates was included in the risk assessment, as well as a discussion on the uncertainties associated with their inclusion in the risk estimates. Potential next steps include inter-laboratory comparisons, in vivo studies, and evaluation of background vs. site soil bioaccessibility.

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Remediation of Chlorinated Hydrocarbons Utilizing HRC

Thomas Brady

Site in Cherry Hill, New Jersey with groundwater impacted with TCE (7,000 ug/l), DCE (3,000 ug/l), and Vinyl Chloride (30 ug/l). Based on the presence of the degradation compounds it was determined that biodegradation had occurred but the reaction had stopped based on the concentrations in groundwater remaining stagnant for several years of monitoring. HRC was selected to restart the anaerobic degradation of the compounds. The HRC was injected over a six month time frame. Groundwater was monitored post injection to verify degradation. Over a two year time frame the concentrations of TCE reached non-detect. The concentrations of DCE were at 2,300 and the Vinyl Chloride was in the teens indicating that the biodegradation had effectively treated the daughter products of the TCE. Continued monitoring of the groundwater revealed that the concentrations of DCE and Vinyl chloride have remained the constant indicating the biodegradation reaction has once again stalled. A second round of HRC will be injected to reactivate the biodegradation process with results due in the Fall of 2013.

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Influence of Pollution Levels Generated in Mexico Valley over the Air Quality in the Toluca City Metropolitan Area

David Chuquer-Sola and Vicente Fuentes-Gea

In this job we analyze the transport of PM$_{10}$ between Mexico City Metropolitan Area (MCMA) and Toluca City Metropolitan Area (TCMA). For this, we evaluate the topography of the area of study to find the factors that limit the pass of pollutants. We identify that the PM$_{10}$ has the best characteristics to evaluate the transport of pollutants. After that, we execute meteorological models with CALMET of events previously determined, discriminating days with statistical tests and establishing days in which the wind fields and mixing heights obtained, favor the transport between the two cities. Moreover, this model allows to determinate the principal pathway that goes the pollutants from a city to another. Next, we execute dispersion models with CALPUFF in the selected days, taking the information of the National Emissions Inventory of Mexico, finding that the model represent moderately the measured values of PM$_{10}$ ($d=0.33-0.57$). Finally we execute a series of CALPUFF configurations to quantify the influence of one city over the other. Of the study we conclude that both cities, in selected events in April and May of 2003, have important importation and exportation of PM$_{10}$.

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Potential for Phytoextraction of Lead and Cadmium by Atriplex Lentiformis

Rohan D'Souza, Mayank Varun and Manoj Paul

Heavy metals, such as cadmium (Cd) and lead (Pb) are important environmental pollutants, particularly in urban areas with high anthropogenic pressure. In a greenhouse study the potential of Atriplex lentiformis, a hardy halophytic plant, to remediate Pb and Cd in soil was evaluated. Plants were grown in soil spiked with 300, 600, 1200 mg kg$^{-1}$ Pb and 50, 100,150 mg kg$^{-1}$ Cd, individually. Soils and plants (root and shoot) were analyzed for metal content at 30, 60, 90 and 120 days. Accumulation trends and growth were characterized. Metal uptake increased with concentration and exposure period. Maximum uptake was 437.2 mg kg$^{-1}$ root; 782.2 mg kg$^{-1}$ shoot for Pb and 39.1mg kg$^{-1}$ root; 27.3 mg kg$^{-1}$ shoot for Cd. Although growth was delayed initially, it was comparable to control at the end of the study. In a subsequent study, manure, EDTA, and VAM [Vesicular Arbuscular Mycorrhiza] were tested as amendments to improve metal uptake in A. lentiformis. EDTA showed most promising results. Statistically significant increase in root length, shoot length and biomass was observed in treatments with soil amendments. One Way ANOVA indicates a significant difference in mean metal content in root and shoot in both studies. Up to 19.0% and 11.1% reduction in soil Pb and Cd content was obtained in EDTA treatment v/s 10.7% and 5.9%, respectively in control. A. lentiformis exhibited BAC (Bioabsorption Coefficient) and TF (Translocation Factor) greater than 1 showing good potential as a Pb phytoextractor. EDTA application further enhanced the potential by increasing the BAC and TF values. Therefore, A. lentiformis appears to be a promising candidate for phytoremediation, especially for Pb, in places with limited scope for regular monitoring and follow up.

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Presenting Author: Rohan D'Souza
Autotrophic Denitrification in Marine Sediment Remediation

Herbert Han-Ping Fang

Sulfide-driven autotrophic denitrification was found to be the dominant process in a marine sediment remediation. The effect of nitrate concentration on denitrification rate, microbial community and byproducts accumulation were investigated in this study. Microorganisms which were phylogenetically closely related with *Sulfurimonas denitrificans* of ε-Proteobacteria and *Thiohalomonas denitrificans* of γ-Proteobacteria were found as the major autotrophic denitrifiers. Nitrate concentration was demonstrated to have selection effects on denitrifying microbial community as revealed by denaturing gradient gel electrophoresis (DGGE). Denitrifiers enriched at 30 mmol/l NO₃⁻ has higher diversity (H=1.97) than other two groups (10, and 80 mmol/l NO₃⁻) according to Shannon index. Denitrification showed zero order reaction kinetics when nitrate concentration was higher than 4 mmol/l. Neither absolute nitrate concentration nor overall nitrate/AVS ratio acted as the determinant for denitrification byproducts (*i.e.* N₂O and NO₂⁻) accumulation. The limitation of sulfide due to low mass transfer might be the reason for these byproducts accumulation.

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Contribution of Wall and Bed Shear Stress on Erosion and Sedimentation of Waterways

Manoochehr Fathi-Moghadam and Babak Lashkar-Ara

Shear stress is a key parameter in correct estimation of erosion and sedimentation in rivers and natural waterways. A novel technique is proposed in this study to determine wall and bed channel boundary shear stress based on momentum approach. Results showed considerable improvement of the previously estimated shear stresses which were based on the energy method. The energy and momentum approaches were used for flow in a 0.8 m wide flume to determine contribution of wall and bed shear stress on total boundary shear. The hydraulic grade line was measured in energy method while a frictionless system (Knife edge flume) was used for the momentum measurements. The local boundary shear stress was measured using a 4-mm diameter Preston tube connected to a differential pressure transducer and a data acquisition system. The calibration curves proposed by Patel were used to correlate the pressure readings and shear stress. The results were adjusted by the total shear force calculated from the energy and momentum methods. A nonlinear regression-based technique was carried out to develop equations and determine the percentage of wall and bed shear stresses on the wetted perimeter of smooth and rough rectangular flume. The experimental measurements of wall and bed shear forces reveals considerable effect of aspect ratio on percentage of wall shear force. The results showed that contribution of wall shear to the total boundary shear decreases by 10 fold when the aspect ratio increases from 1 to 20. Normalized wall and bed shear stresses demonstrate a rapid growth of shear stresses in small aspect ratios. However, normalization of the wall and bed shear stresses with hydraulic radius granted more correct results and revealed a reasonable decrease of the mean wall shear stress with increase of aspect ratio. For the bed shear stress, the effect of aspect ratios more than 6 does not show to be significant.

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Characterization of Interspecies Hydrogen Transfer for Efficient Dechlorination of Chloroethenes

Hiroyuki Morioka, Naruaki Sato, Teruaki Hanji, Tomoaki Sagisaka, Kenji Suzuki, Hiroya Ueda, Syuji Yamamoto and Hiroyuki Futamata

It is known that an efficient dechlorination of chloroethenes needs to maintain appropriate hydrogen interspecies transfer. However, it is unclear that what kinds of microorganism are key players and that how to control them in a complex system. We analyzed microbial community structures in transferred enrichment cultures which exhibited high and low chloroethenes-dechlorinating activity (5th-LS and 6th-LS cultures). Citrate (1.8 mM) was used as sole and initial electron donor in the cultures. Another different points between 5th-LS and 6th-LS cultures on the dechlorination were the pattern of methane-production and acetate-consumption. Clonal analyses targeting 16S rRNA gene revealed that the community structures of Bacteria were similar but those of Archaea were different from each other. Interestingly, methanogens communities were dramatically changed. Hydrogenotrophic methanogens and aceticlastic methanogens dominated approximate 80% of methanogens in 5th-LS culture and 6th-LS culture, respectively. These results demonstrated that hydrogenotrophic methanogens did not occur the competitive inhibition for dechlorination but aceticlastic methanogens did. Although standard Gibbs free energy ($\Delta G^\circ{}$) values for methane production from acetate by these methanogens are same ($\Delta G^\circ{}$ = -30.96 kJ reaction$^{-1}$), methanogenesis of hydrogenotrophic methanogens is a coupling reaction of anaerobic acetate oxidation ($\Delta G^\circ{}$ = 104.6 kJ reaction$^{-1}$) and methane production ($\Delta G^\circ{}$ = -135.56 kJ reaction$^{-1}$). These results suggested that the interspecies hydrogen transfer between anaerobic acetate oxidizers and dechlorinators is significantly important for efficient chloroethenes-dechlorination in the enrichment cultures.
Comprehensive Rethinking of Wastes from Mine Sites into Resources

James Jacobs and Stephen Testa

Mining wastes and the associated environmental degradation have long plagued communities with abandoned mine sites. Comprehensive, and large-scale community driven processes and workplans are needed to convert abandoned mine sites and associated mining wastes into productive reuse. One of the greatest challenges at former mine sites is acid rock drainage (ARD) which is created from the oxidation of pyrite and other iron sulfide minerals exposed to water and oxygen in the atmosphere in the presence of iron and sulfur oxidizing microbial communities. The resulting biogeochemical reactions create sulfuric acid and low pH waters, which in turn, solubilize other associated metals such as aluminum, manganese, iron and heavy metals contained in the surrounding rocks and sediments. In addition to recycling water from former mine pits, acid rock drainage can be used as a source of resources including hydraulic fracture stimulation fluids for unconventional oil and gas production, but significant challenges exist. In several cases in West Virginia, Maryland and Pennsylvania, treated mine waters are being used to grow rainbow trout as aquaculture benefits from the dewatering of excess shallow groundwater from coal mines in areas where mine drainage problems are common. Recovery of metal resources and products can be enhanced by optimizing the microbial environment which favors bioleaching and precipitation using various biomining techniques. Wetlands construction provides valuable wildlife habitat and passive ecosystem services while passively treating acid drainage. Acid rock drainage case studies associated with water reclamation, aquaculture, biomining, community redevelopment, and wildlife habitat creation will be discussed in the context of sustainable remediation and green resource extraction practices. Long-range community planning processes can be linked to environmental and economic solutions to seemingly independent challenges of mineral resources, water availability, local food production, ecosystem restoration, education and training benefits and employment opportunities. The talk will focus on opportunities as well as challenges of mining waste reclamation.

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Presenting Author: James Jacobs
Removal of Pb and Ni by Manganese Oxide Nanoparticles Decorated on Mesoporous Expanded Graphite

Sunmi Choi, Chaeyoung Lee, Byung-Uk Bae and Seoktae Kang

We have shown that the manganese oxide nanoparticles synthesized on mesoporous expanded graphite (MnOx-EG) is an effective sorbent material for toxic heavy metals such as Pb and Ni. The specific surface area, adsorption kinetics, and water permeability of MnOx-EG were compared to those of manganese oxide nanoparticles (birnessite) and activated carbon (AC). The surface areas of MnOx-EG, birnessite, and AC were determined to be 92 m²/g, 47 m²/g, and 965 m²/g, respectively, using the Brunauer–Emmett–Teller method. Batch experiments were carried out to determine the adsorption kinetics and mechanisms of Pb and Ni by MnOx-EG. Although MnOx-EG had an adsorption capacity of 123 mg-Pb/g and 21 mg-Ni/g, which were about 70% of adsorption capacity of birnessite, the permeability coefficient of MnOx-EG was measured to 1.02x10⁻² cm/s, which was more than two orders higher than that of birnessite. The kinetic data of Pb and Ni adsorption by MnOx-EG were best described by a pseudo-second-order equation, indicating their chemical adsorption. This work demonstrates that the MnOx-EG can be considered as a filling material for the potential permeable reactive barrier as well as novel adsorbent for heavy metals.

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Enhancement of Fermentative Hydrogen Production from Microalgae Using Combined Pre-treatment

Jaemin Choi and Chaeyoung Lee

The Chlorella vulgaris is known as the main type of microalgae with high sugar content and starch-based biomass. The cell wall is usually made of starch and polysaccharide but can differ due to cultivation as well as environment. This study was conducted to improve fermentative hydrogen production from Chlorella vulgaris in batch reactors using acid-thermal combined pre-treatment. Three experiment parameters of HCl concentration, thermal temperature and thermal reaction times are considered. The optimization of three experiment parameters is conducted using response surface methodology. The response values used hydrogen yield. The highest average hydrogen yield of 47.5 mL H₂/g dry cell weight (dcw) was obtained at the center point represented by the coded variables of <0.0.0>. To retry the statistical experimental design, a confirmation test was conducted at the optimal condition. The confirmation test result was close to the predicted hydrogen yield. The compositions of sugar in Chlorella vulgaris without pre-treatment showed only 13 g/g dcw for sucrose, while Chlorella vulgaris with combined pre-treatment showed 3 g/g dcw for fructose, 21 g/g dcw for glucose and 16 g/g dcw for maltose. SEM(Scanning electron microscope) image analysis showed that average diameter of Chlorella vulgaris without pre-treatment was 2.7, but with combined pre-treatment was 0.7.

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Numerical Simulation on the Oil Bioremediation Process of Real-scale Soil Using a Microbiological Model

Yao Luan and Tetsuya Ishida

In Japan, with the decline of overall vehicle sale and increase of eco-cars, in recent years the number of gas stations is declining. For the reutilization of those abandoned gas stations, it becomes an important issue to decontaminate and remedy the contaminated soil by oil. Several methods can be used for remediation, such as combustion, distillation, washing and bio-decomposition. The bio-decomposition, which is known as bioremediation, is to decompose and remove oil using microbials. Bioremediation is a complicated bio-chemo-physical process. In order to understand the overall process and evaluate its effectiveness, it is necessary to establish a numerical model based on a coupled bio-chemo-physical approach.

In the authors’ research group, to evaluate and predict the composting process of organic waste based on aerobic decomposition, a microbiological reaction model has been developed, considering the factors such as the growth and death of microbials, and the carbon-nitrogen (C/N) ratio of the organic waste. In this paper, the study is focused on the microbials in oil contaminated soil rather than in organic waste. A bioremediation model is established to simulate the decomposition of oil by microbials, in which a similar approach with that of organic waste is used. Besides, the decomposition rate of oil is influenced by factors such as oil concentration, temperature, water content and oxygen supply. Therefore, based on mass or heat conservation equation, the distributions of those factors in contaminated soil are simulated using three-dimensional finite element analysis, and coupled with the microbiological reaction model. Finally, the proposed model is applied to the bioremediation process of a real-scale oil contaminated soil. The influence of oil concentration, temperature, water content and oxygen supply are discussed by changing those parameters in the analysis. The results show that the overall process of bioremediation can be reproduced using the proposed model.

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“Temporal Hot Spots” – A Conceptual Framework for Assessing Indoor Air Exposures at Vapor Intrusion Sites

Loren Lund, Dave Folkes, Jeff Kurtz and John Lowe

Temporal variability in indoor air concentrations creates uncertainties that affect the ability to assess, mitigate, and close vapor intrusion (VI) sites. High-resolution studies of VI suggest that indoor concentrations might follow a pattern of localized variability that can be characterized as “temporal hot spots”, whereby a majority of the exposure occurs during a small percentage of the year. If this is true, a small number of 24 hour tests might not adequately represent the average exposure over time. Current responses to address these uncertainties include increasing the amount and frequency of indoor air sampling at VI sites and implementing preemptive mitigation, both of which may significantly increase the cost of managing risks at VI sites. These appear oriented to prevent exposure to temporal hot spots which may or may not be significant for long-term human health risks. On the other hand, a large number of homes have been routinely tested over a number of years at major VI sites, without indication of “temporal hot spots”, suggesting that the behavior observed in the few high-resolution studies available may reflect only a limited range of conditions. To that end, this paper integrates summary statistics based on long-term VI sites including CDOT, Redfield and Hill AFB with the high-resolution hourly sampling from recently-completed high-resolution studies of VI in research houses. Groups of hourly concentrations are drawn from the high-resolution data sets through bootstrapping and used to create simulated 24-hour average concentrations, which are then compared with the measured 24-hour concentrations from the VI sites. Lessons are drawn from these analyses regarding the likelihood of temporal hot spots, appropriate sampling frequency and averaging times for indoor air sampling, appropriate uses of statistical methods and the effectiveness of indoor air sampling in characterizing both long- and short-term exposures.

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Presenting Author: Loren Lund
Natural Attenuation at the National Crude Oil Research Site in Bemidji MN &
Future Opportunities for Environmental Research and Equipment Testing
Projects

James McCann and Mark Toso

The National Crude Oil Research Site dates back to 1979, when a sudden pipeline rupture released
10,000 barrels of crude oil to the land surface and shallow subsurface. In 1983, research began at the
site through the support of the U. S. Geological Survey’s Toxic Substances Hydrology Program.
Hundreds of scientists from across the globe have visited this “underground observatory” to study the
effects of a petroleum release including the physical, chemical and biological processes driving the
degradation and transport of petroleum.

Research at the site was and still is instrumental in documenting the process of natural attenuation.
Tremendous amounts of data have been generated by site research and both the LNAPL and dissolved
phase contamination has been well defined in all dimensions such that researchers for over 30 years
have been able to pinpoint the location of the LNAPL front within a few feet. What this tells us is that
despite a limited number of wells, borings, and sampling events at remediation sites, less intensive (and
less expensive) investigations may be sufficient to assess risk.

The site consists of three light non-aqueous phase liquid (LNAPL) bodies and a surface impacted area
known as the spray zone which contains hydrophobic soils. There are close to 200 monitoring wells and
over 80 vapor monitoring locations in addition to hundreds of soil cores taken at just one of the three
LNAPL bodies. The site is available for ongoing approved research for a variety of topics and
supplemental funding is available. Research departments from private industry and consultants looking
for an instrument/ equipment test site are also encouraged to avail of the site resources.

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Presenting Author: James McCann
GIS Analysis of Environmental Issues in the Lower Savannah Watershed

Edmund Merem, Joan Wesley, Peter Isokpehi, Samu Iweabuara, Siddig Fageir and Marshand Crisler

Watersheds are nature’s boundaries made up of land areas that catch rain and drain into specific water bodies. Over the years, state agencies have been adopting watershed approach to restore water quality and to comply with federal policies. However, the continuous analysis of watershed trends using geospatial technologies plays an important role in the conservation of water bodies. In Georgia and South Carolina, the Lower Savannah river supports a variety of wildlife, biodiversity and agricultural activities. Many stressors from land use in these areas such as toxins continue to degrade the biological and ecological integrity of the watershed.

Notwithstanding these problems, very little has been done to analyze efforts among agencies in containing pressures mounted from land uses and human activities along the lower savannah watershed. This has resulted in altered hydrology, degradation, habitat disturbance and intense use of water resources. In light of these issues, there is an urgent need for a mix-scale analysis of these trends using GIS in the study area. This paper adopts geo-information systems based method and primary data to assess the status of the watershed. Emphasis is on the issues, factors, current efforts and strategies for watershed protection and future line of actions.

With the results showing declines in environmental resources, widespread use of agrochemicals, impairment of the watershed, and the spatial dispersion of threats from land use practices. There are numerous initiatives among agencies to rehabilitate the watershed. In terms of future lines of action, the paper offered suggestions including the need for continuous analysis of watershed trends in the study area.

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Presenting Author: Edmund Merem
Removal of Trace Amounts of Heavy Metal from Seawater Using a Novel Metal Binding Protein

Phuc Huu Ba Nguyen, Herbert Mao, Aaron Ong and Roger Acey

We have been working to develop a novel “heavy metal sponge” for the removal and recovery of toxic and precious metal. The technology is based on a low molecular weight protein known as metallothionein (MT). The protein has the unique ability to selectively bind heavy metals, e.g., lead, mercury, gold, and platinum. We have recently shown that the molecule also binds lanthanum, europium, and uranium. The protein is expressed in bacteria and purified to homogeneity from cell lysates by a simple and cost effective method using FPLC anion exchange chromatography. The purity of the preparation was confirmed by SDS-PAGE.

The purified MT was used to determine the potential for removing trace amounts of heavy metal from seawater. The protein was mixed with seawater containing 100 ppt (trillion) of $^{109}$Cd. The protein/metal complex was then collected using a membrane filter centrifugal device and the flow through assayed for radioactivity. The efficiency of metal binding was determined from the radioactivity in the flow through. Under these conditions, 88% of the metal was removed from the seawater after a single centrifugation. Funded in part by a grant from CSUPERB.

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Presenting Author: Phuc Huu Ba Nguyen
In Situ Bioremediation of a Large Chlorinated Solvent Release at a California State Superfund Site

Danny Nunez and Bryan Vigue

A large chlorinated solvent release was identified near a commercial dry cleaning facility in Santa Rosa, California. Contaminants were migrating off-site and beneath a nearby public school. Groundwater sampling measured concentrations of the chlorinated compounds perchlorehene (PCE) as high as 4,100 ug/L and trichloroethene (TCE) as high as 120 ug/L resulting in immediate remedial action. This site is unique in that it is covered by the California State Superfund under the direction of the DTSC and within the jurisdiction of the North Coast Regional Water Quality Control Board (RWQCB). The remediation goal was to reduce the PCE and TCE levels to below the California maximum contaminant level (MCL) of < 5 ug/L in all monitoring wells. To achieve this goal, in situ, enhanced anaerobic bioremediation (EAB) was used to biologically degrade the dissolved-phase chlorinated plume. In order to effectively facilitate the EAB process, an injectable substrate with a unique 3-stage electron donor release profile was required and selected for application via mobile direct-push injection. This presentation will discuss the site, the treatment approach and the overall performance results.

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Presenting Author: Danny Nunez
Preparation of Polyurethane Composite Adsorbent and its Enrichment of Polychlorinated Biphenyl from Environmental Sample

Folasayo Olorundare

Polyurethane (PU) polymer composite was synthesised by cross-linking a glycol-prepolymer and polyol with isocyanate linker together with other additives as filler. The comparison of the adsorption properties of the polymer synthesized using different ratios of 1,6-hexa methylene diisocyanate (HMDI) and 4, 4′ methylene diphenyl diisocyanate (MDI). The diisocyanate, together with cyclodextrin (β-CD), activated carbon (AC), and raw tassel (RT) were used to preconcentrate three mixtures of polychlorinated biphenyl (PCB 105, PCB 126 and PCB 153) from environmental samples. The polymers were successfully synthesised and applied in the extraction of PCB from a large volume (0.5 L) of wastewater solution. The extraction procedure using solid-phase extraction (SPE) resulted in a short extraction time of about 10 min and preconcentration of PCB from 500 mL of water sample. With the eluent condensate to about 1 mL, recovery percentage of the PCB ranged between 90% and 95%. While the limit of detection (LOD), limit of quantification (LOQ) and relative standard deviation (RSD) results ranged from 0.0048 ng/mL to 0.013 ng/mL, 0.015 ng/mL to 0.04 ng/mL and 1.50% to 4.4%, respectively. The experimental tests showed good preconcentration results of trace levels of PCB using the synthesised PU polymer adsorbent composites.

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Presenting Author: Folasayo Olorundare
The Fates of Heavy Metals in Electrocoagulation Process

Ronna Jane S. Palacios, Do-Gun Kim and Seok-Oh Ko

Recently, electrocoagulation (EC) has attracted attention for heavy metals removal in aqueous media because of the high removal rate, low cost, versatility, and easy automation. In this study, Pb(II), Cd(II), and Cu(II) removal by EC using iron electrodes was evaluated and the fates of the heavy metals and iron were investigated via sludge characterization. The removal rate of Pb(II), Cd(II), and Cu(II) increased as current density increased, as initial heavy metal concentration decreased, and as reaction time increased. The pH increased by the OH⁻ produced at cathode. The pH increase was slower when initial heavy metal amount increased because more OH⁻ was consumed for metal hydroxides formation. The X-ray diffraction (XRD) patterns of the sludge indicated that the sludge was poorly crystalline. However, the peaks of magnetite, lepidocrocite, Pb(OH)Cl, Cd₂(OH)₃Cl, Cu₂O and CuCl were identified. It indicates that chloride ion, added as electrolyte, takes part in the heavy metals removal via forming precipitates and that a fraction of Cu(II) was oxidized during EC. The chemical species found in the XRD patterns were significantly different from those predicted by chemical equilibrium analysis. Irregular shaped particles were observed in the transmission electron microscopy images of the sludge produced from Pb(II) and Cu(II) removal, while stick-like structures, implying the existence of lepidocrocite, were found for Cd(II) sludge. It indicates that Pb(II) and Cu(II) were removed via forming precipitates but Cd(II) was removed via adsorption onto lepidocrocite particles formed with the dissolved iron, which is originated from iron electrode dissolution. The results in this study suggest that many reactions, such as precipitation, adsorption, and chemical oxidation/reduction in the vicinity of the electrodes take part in the EC process.

Keywords: Electrocoagulation; heavy metal; sludge; fate

Acknowledgement: This research is supported by Korea Ministry of Environment as "The GAIA Project".

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Presenting Author: Ronna Jane S. Palacios
Removal Characteristics of Humic Acid during Electrocoagulation with Aluminum Electrodes

Ronna Jane S. Palacios, Do-Gun Kim and Seok-Oh Ko

Humic acid (HA) is as the major component of natural organic matter, significantly affecting the fate, reactivity, and transport of pollutants. HA also is of issue because HA affects the performance of a water/wastewater treatment efficiency and, most of all, HA is a major foulant of membranes used for water treatment. In this study, HA removal by electrocoagulation (EC) using Al electrodes was evaluated and the change of HA property was investigated. HA removal was faster with Al electrodes than with Fe electrodes. The zeta potential of the sludge from EC with Al electrodes was negative while that of Fe electrodes was positive. It was observed that HA was desorbed from the EC sludge collected after HA removal, as pH was increased by adding NaOH and, as a result, as zeta potential decreased. The Al sludge produced during EC was classified to monomeric Al species (Ala), medium polymer Al species (Alb), and colloidal or solid Al species (Alc), by Ferron analysis. Using Al electrodes, HA removal rate and Alc concentration increased but Ala concentration increased, as current density (CD) increased and as pH decreased. The synchronous fluorescence spectra, UV/Vis spectra, and molecular size distribution of dissolved HA showed the decrease aromaticity and high molecular weight fraction of HA, after EC. The results in this study indicate that the electrostatic attraction and the amount of solid phase Al species greatly contribute to the HA removal by EC. In addition, the more condensed, high molecular weight, and highly aromatic structure of HA is preferentially removed by EC, probably because of its lower zeta potential than low molecular weight fraction. It is also expected that the removal of high molecular weight fraction by EC can reduce the fouling of the following membrane process.

Keywords: Electrocoagulation; Humic Acid; Aluminum specie; Ferron analysis, zeta potential

Acknowledgement: This research is supported by Korea Ministry of Environment as "The GAIA Project".

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Presenting Author: Ronna Jane S. Palacios
Coal Dust Exposure among Coal Mine Workers: A Case Study

Gopal Pathak

During the last few decades coal dust related lung diseases has increasingly been recognized as a major health problem in industrialized countries. Mineral operations are usually dusty and dust is the major health hazard in mines. Accidents such as fall of broken roof appear to cause the maximum number of deaths in a mine. Yet the fact is that for each man who is killed due to fall of ground in mine, about ten die from the dust inhalation, according to a British experience.

The inhalation of air borne coal dust over a long period and in large concentration gives rise to many lung diseases among the coal mine workers like asthma, bronchitis and even pneumoconiosis, which is commonly known as Black lung disease. The main danger of pneumoconiosis is that it is liable to complicated by tuberculosis, which is normally fatal unless diagnosed and treated at an early stage. The inhalation of 0.5-5 micron size coal dust particles have been held responsible for causing pneumoconiosis. Also the shape of the particle is an important factor. Chemical composition of the coal dust particle has a major role to play in causing pneumoconiosis.

Jharia Coalfield is situated in the Eastern part of India having coking coal as an important reserve. The present paper deals with the coal dust exposure among coal mine workers in the region. Further it also explains the preventive measure to be taken in this regard.

Keyword: Health hazard, coal dust, pneumoconiosis

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Presenting Author: Gopal Pathak
Environmental Sequence Stratigraphy (ESS) and Membrane Interface Probe (MIP) Guide a Focused and Cost-Effective Remedial Design

Assaf Rees and Anthony Lizzi

A commercial site in Southern California operated as a gasoline station, a hazardous waste site, and a vehicle repair shop. Site investigations revealed subsurface impacts in soil and groundwater consisting of petroleum hydrocarbons and chlorinated solvents. 40 tons of impacted soil were excavated and groundwater monitoring wells were installed into shallow and deep saturated zones. The residual contaminants are chlorinated VOCs in groundwater, mainly trichloroethene and cis-1,2-dichloroethene, detected at concentrations below 100 µg/L except in one well (MW-2), where concentrations are an order of magnitude higher. An Interim Remedial Action Plan (IRAP) included soil-vapor extraction and in-situ bioremediation using reductive dechlorination (RD) for treating a 40’ by 40’ area around well MW-2 over a 20’ interval.

A revised approach was formulated to improve the site conceptual model using high-resolution characterization tools (MIP and ESS) to guide a more cost-effective remedy and minimize the formation and potential off-site migration of toxic daughter products (vinyl chloride). 13 MIP boreholes were advanced to 60 feet bgs generating 15,000 data points that were used to create a dynamic 3-D model of the impacted area. Data revealed impacted groundwater extending further horizontally than the IRAP approach but contained within only 7’ of vertical interval. ESS is based on interpretation of depositional environments combined with existing site data to identify geologic heterogeneities and favorable pathways for remedy delivery, which is key to the success of the remedial action. ESS identified laminations of thin continuous sand layers across the top 20’ of the saturated zone, which was previously logged as only fine-grain sediments (silts and clays). These are the likely conduits for contaminant transport as well as for remedy delivery. Remedial designs were revised to a) perform enhanced RD in the plume core via injection of a slow-release electron donor into the continuous sand layers, and b) install a zero-valent iron abiotic reduction barrier along the property boundary to prevent off-site migration.

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The Relationship between Co-Located Soil Vapor and Groundwater Samples and Implications for Vapor Intrusion Risk Assessments

Kimberly Souder, Chris Stubbs and Emily Lisker

Recent US Environmental Protection Agency and California Environmental Protection Agency guidance documents have stressed the importance of multiple lines of evidence in performing vapor intrusion risk assessments; however, there are limited options at sites with no current buildings. In instances where groundwater is the source of contamination, concentrations of chemicals in groundwater samples are often strongly correlated to concentrations of chemicals observed in shallow soil vapor samples. However, a number of chemicals (i.e. benzene) undergo more complicated processes like biodegradation, and the concentration of those chemicals observed in groundwater samples are only weakly correlated to the concentration of chemicals in soil vapor samples. We have examined a combination of groundwater and soil vapor samples (co-located spatially and temporally) and produced correlation plots for a number of chemicals to observe the strength of correlation. Some chemicals (i.e. chloroform) have a very strong relationship between groundwater and soil vapor samples, while other chemicals do not (i.e. benzene). We have also performed calculations predicting soil vapor concentrations from groundwater concentrations using partitioning, diffusion, and biodegradation models to evaluate the quality of these models in this particular example. This case highlights the importance of collecting shallow soil vapor samples, especially at sites without a building present, in addition to groundwater or deeper soil vapor samples. While deeper, near-source groundwater or soil vapor samples can provide valuable information, they also may over-estimate risks associated with exposure to chemicals that biodegrade and additional, shallower soil vapor samples are important to more accurately assess site risks.

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Air Sparging and Automated Solar spark Vent Flares – Sustainable LFG Mitigation for Slow LFG Migration

Ronald Johnson and Aklilu Tesfamichael

Capping of a small and inactive landfill site, located in San Diego County CA, forced landfill gas (LFG) to slowly migrate laterally. LFG was detected in a few perimeter probes above the regulatory threshold of 5% methane by volume. As part of controlling LFG migration and achieving regulatory compliance, LFG mitigation system consisting of air sparging and automated solar spark vent flares was designed, installed and operated.

The two LFG mitigation systems were designed to function in a complementary way. The solar spark vent flares were designed to extract and combust LFG and gradually depressurize the landfill site, and create an inward gradient to force LFG flow towards the center and reduce outward migration with time, while the air sparging in the perimeter wells were designed to provide a near-term reduction in methane concentration through microbial destruction of methane by creating aerobic condition near affected perimeter probes. Each automated solar spark vent flare is fitted with custom made inline solar powered blower to assist with active extraction and combustion of LFG. The flares are also fitted with programmable logic control (PLC) to prevent passive venting, and minimize un-flared discharge into the atmosphere through temperature sensors, automated valve and automatic blower shutoff mechanisms.

The mitigation system has been successfully operating for more than 18 months now, and compliance has been achieved and maintained at perimeter probes. The fixed gases data in perimeter probes collected bi-weekly over the O&M period were used to evaluate the role of aerobic oxidation and the impact of the automated flares in achieving compliance. The O&M data analysis shows that LFG migration has been reduced as a result of the concurrent application of air sparging and solar spark vent flares. The O&M experience at the site also showed that the mitigation approach could be reliable, sustainable and more cost effective than traditional LFG collection and control systems.

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Using Stable Isotopes as Tracers to Analyze the Impact of Ship Emissions

Nitya Timalsina

The production of nitrate aerosols has major implications for public health and the environment. Oxides of nitrogen (NOx) not only propagate the formation of ground-level ozone that harms vegetation and health but also contribute to acid rain. Nitrate aerosols also affect Earth’s radiation balance directly by scattering and absorbing short wavelength radiation and indirectly by affecting planetary albedo and the lifetime of clouds. They are formed naturally through bacterial processes (nitrification oxidizing ammonia to NO2 or NO3), lightning (oxidation of atmospheric N2 to NOx), and biomass burning (oxidation of organic nitrogen) as well as anthropogenically through fossil fuel combustion, primarily for the purpose of energy production or transportation. On the global scale, perturbations to the planet are largely caused by anthropogenic sources of nitrate, not natural. Ships, which transport 90% of the world’s consumer goods, are estimated to contribute twenty to thirty percent of nitrate-related pollution while also emitting other harmful particles like sulfates. In a polluted urban environment, interactions between gases and particles produce complex compounds that are challenging to measure with most analytical methods. Using oxygen triple and nitrogen dual isotopic measurements of nitrate, we seek to analyze marine aerosol samples from Hong Kong, China. Connecting nitrate concentration data with isotopes of nitrogen Δ15 N and oxygen isotopes Δ17 O and Δ18 O will yield a novel and effective method that could enable quantification of nitrate aerosol sources by providing parameters necessary to model and evaluate the sources of nitrate pollution. The combination of investigating stable oxygen and nitrogen isotopes, in particular, is a useful tool that will allow us to delineate the local versus long-range transport of pollutants and understand the physicochemical and photochemical processes occurring in a complex mixture of gases and particulate matter en-route to sink regions.

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Meeting Challenges in Decision-Making When Evaluating Risks Associated with Emerging Chemicals

Usha Vedagiri, Jill Hedgecock and Heather Loso

Within the US, as in other countries, there is increasing concern about the release and potential health effects of “unconventional” chemicals that may be commonly used in product manufacture and distributed widely in the environment. California’s Safer Consumer Products regulation and Europe’s Registration, Evaluation, Authorisation and Restriction of Chemical (REACH) program, attempt to regulate the use of such chemicals. However, adequate information regarding environmental fate and human and ecological toxicity are often lacking for these chemicals, presenting difficulties in risk evaluation and decision-making. This presentation will cover example case studies for a few classes of emerging chemicals that are widely distributed in the environment: e.g., flame retardants such as polybrominated diphenyl ethers (PBDEs) and perfluorinated compounds (PFCs) and explosives such as nitrotoluenes and perchlorates. Based on a world-wide review of information sources, an approach for identifying information sources for fate and transport attributes and for acute and chronic toxicity information for human health and for aquatic ecological receptors (including birds and marine mammals) is described. The methods for evaluation of the quality of data available and identification of data gaps, including the adequacy of the existing database, as well as the impact of these uncertainties on risk estimates and, ultimately decision-making, will be presented.

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Presenting Author: Usha Vedagiri
Evaluation of Attenuation Factors and Foundation Type in Predicting Vapor Intrusion

Nadine Weinberg, Carolyn Grogan, Jason Manzo, and Pam Barnett

In order to more fully understand vapor intrusion at residential homes, the United States Environmental Protection Agency (U.S. EPA) has developed several technical documents. U.S. EPA’s Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings technical document provides data on attenuation factors (AFs) from groundwater, soil gas, and sub-slab soil gas to indoor air and indicates that attenuation can be highly variable, especially for certain media. In this paper, data from a primarily residential, vapor intrusion site in Moraine, OH (site) was used to evaluate the AFs recommended by U.S. EPA for soil gas, groundwater, and sub-slab soil gas.

The data collected from the site was used to calculate site-specific AFs for groundwater and soil gas from the right-of-way and sub-slab soil gas data from the 45 properties. The results are compared to U.S. EPA’s database of AFs including both the range of AFs calculated by U.S. EPA and the recommended AFs. Deviations from U.S. EPA’s database are explained and factors that could affect attenuation are identified including depth to groundwater, subsurface geology, background sources, and building conditions. In addition, AFs were evaluated by residential foundation type. At this site, homes were primarily single-family and consisted of slab-on-grade, basement, crawlspace, and a combination of these three foundations.

The AFs calculated for the site indicates that the sub-slab to indoor air AF’s recommended by U.S. EPA are supported by the site-specific data. Any deviations from the recommended AFs are explained by the site-specific building conditions. In addition, data from homes with crawlspace construction indicates that VI was generally not occurring at these homes. The potential use of foundation type to predict or identify homes with a greater potential for VI will be presented in greater detail.

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Intrinsic and Enhanced Biodegradation of Polycyclic Aromatic Compounds in Oil Residues

Alan Weston, Sophia Dore, Christa Nunn, Donald Pope and Paul Ranieri

Polycyclic aromatic compounds (PAH) are a component of oil and petroleum compounds. Due to their complex structure, which is comprised of multiple aromatic rings, they can be slow to biodegrade and resistant to many treatments applied to petroleum hydrocarbons. Additionally, cleanup standards for these compounds are often low since many are carcinogenic. The combination of recalcitrant compounds and low cleanup standards can present a challenge for remediation. In this presentation, two sites that contain PAH will be examined. At the first site, PAH were present in shallow soil and conditions were aerobic. Therefore, the capacity of intrinsic biodegradation to treat these soils to their target levels was investigated. The second site contained very low levels of PAH, however, the cleanup standards in this jurisdiction were extremely low. The effects of low concentrations of PAH on PAH biodegradation will be examined, and methods to enhance biodegradation at these low levels will be discussed. This presentation will provide an understanding of PAH biodegradation at different concentrations and under different conditions, which will assist with the choice of remediation strategy for PAH impacted sites.

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