

## Measurement & Monitoring: 23rd Quarterly Literature Update

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### Advancement of Nucleic Acid-Based Tools for Monitoring In Situ Reductive Dechlorination

Vangelas, K., E. Edwards, F. Loeffler, B.B. Looney.

Paper No: WSRC-STI-2006-00332, 23 pp, Nov 2006

Regulatory protocols generally recognize that destructive processes are the most effective mechanisms that support natural attenuation of chlorinated solvents. In many cases, these destructive processes will be biological processes and, for chlorinated compounds, will often be reductive processes that occur under anaerobic conditions. The existing EPA guidance (EPA, 1998) provides a list of parameters that provide indirect evidence of reductive dechlorination processes. In an effort to gather direct evidence of these processes, scientists have identified key microorganisms and are currently developing tools to measure the abundance and activity of these organisms in subsurface systems. The research presented in this paper continues the development efforts to provide a suite of tools to enable direct measures of biological processes related to the reductive dechlorination of TCE and PCE. The study investigated the strengths and weaknesses of the 16S rRNA gene-based approach to characterizing natural attenuation capabilities in samples. The results suggest that an approach based solely on 16S rRNA may not provide sufficient information to document the natural attenuation capabilities in a system because it does not distinguish between strains of organisms that have different biodegradation capabilities. The results of the investigations provided evidence that tools focusing on relevant enzymes for functionally desired characteristics may be useful adjuncts to the 16SrRNA methods.

[http://www.osti.gov/bridge/product.biblio.jsp?query\\_id=8&page=0&osti\\_id=898370](http://www.osti.gov/bridge/product.biblio.jsp?query_id=8&page=0&osti_id=898370)

### Airborne Chemical Sensing with Mobile Robots

Lilienthal, A.J. and A. Loutfi (Univ. of Orebro, Sweden); T. Duckett (Univ. of Lincoln, UK).

Sensors, Vol 6 No 11, p 1616-1678, Nov 2006

Airborne chemical sensing with mobile robots has been an active research area since the beginning of the 1990s. This article presents a review of research work in this field, including gas distribution mapping, trail guidance, and the different subtasks of gas source localization. The authors focus largely on experimental work rather than publications based purely on simulations.

<http://www.mdpi.org/sensors/papers/s6111616.pdf>

### Airborne Geophysical Surveys for Mapping Acid Mine Drainage

Brown, B., Fugro Airborne Surveys, Mississauga, ON, Canada

2006 SME Annual Meeting and Exhibit & 7th ICARD, March 26-29, 2006, St. Louis, Missouri.

American Society of Mining and Reclamation (ASMR), Lexington, KY. p 1654-1656, 2006

A wide range of environmental studies can be enhanced with helicopter geophysical methods. Airborne surveys cover large areas, mapping conductivity in three dimensions. Once data are acquired, drilling can be targeted on the target zones picked from the geophysics, and only a few drill holes are needed to give some ground truth to the airborne data. Data obtained

via helicopter geophysical methods have been used to assess sites, plan remediation, and monitor the status of subsurface contamination. Data illustrating how scientists have improved the knowledge of drainage, water/contaminant sources, and pathways through fracture systems is presented.

#### Altered Geophysical Response Reflects Changes in Microbial Community Structure in Petroleum Contaminated Sediments

Allen, J.P. (Western Michigan Univ., Kalamazoo); E.A. Atekwana and E.A. Atekwana (Univ. of Missouri-Rolla); S. Rossbach (Western Michigan Univ.).

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS41A-01, 2006

In an investigation of the microbial diversity of a petroleum-contaminated site, the main objective was to characterize the microbial community structure in zones of higher and lower conductivity. Culture-independent 16S rRNA gene libraries were constructed using sediment samples collected from the contaminated and background sites. Diversity indices indicated that the microbial community at the contaminated site contained fewer, more dominant populations, whereas the microbial community at the background site was much more diverse. The microbial communities in and around the aged underground petroleum plume have adapted to the available carbon source (petroleum hydrocarbons) and influence the geophysical and geochemical surroundings through their catabolic activities. The information gained in this study suggests that changes in microbial community structures parallel changes in the geophysical properties of contaminated sediments, providing strong evidence of the feasibility of using geoelectrical measurements for the monitoring of natural or engineered bioremediation processes.

#### Amperometric Detection of Pesticides Using Polymer Electrodes

Ghosh, D., K. Dutta, D. Bhattacharyay, and P. Sarkar, Univ. of Calcutta, Kolkata, India.

Environmental Monitoring and Assessment, Vol 119 Nos 1-3, p 481-489, Aug 2006

An amperometric biosensor has been developed for indirect and precise measurement of pesticide concentration at the ppb level. The method is based on the action of two enzymes--acetylcholine esterase and choline oxidase--immobilized in a polymeric porous network directly on the working electrode of a screen-printed sensor. A polyacrylamide matrix was prepared by copolymerisation of acrylamide and N,N'-methylenebisacrylamide using potassium peroxydisulphate as initiator. A linear relationship was obtained between the range of 0 to 10 ppb.

#### Application of FT-IR for Assessment of the Biological Stability of Landfilled Municipal Solid Waste (MSW) During In Situ Aeration

Tesar, M., R. Prantl, and P. Lechner.

Journal of Environmental Monitoring, Vol 9 No 1, p 111-120, Jan 2007

In situ aeration is an emerging approach to the remediation of abandoned landfills that accelerates mineralization and stabilization of waste organic matter and thus reduces the emission potential of the site. To evaluate the success of the technique, a study of the biological stability of the aerated material was conducted using Fourier transform infrared spectroscopy (FTIR) to identify different stages of organic matter degradation as reflected by changes in the

infrared spectral pattern. Waste samples derived in the course of pilot- and lab-scale aeration experiments were characterized by FTIR and a set of conventional parameters describing biological stability. Visual spectra interpretation was found to be appropriate in proving a reduced emission potential of initially rather reactive waste. When visual spectra interpretation was limited, cluster analysis was applied successfully to differentiate between original and aerated waste samples.

#### Assessing Nickel Bioavailability in Smelter-Contaminated Soils

Everhart, J.L., D. McNear Jr., and E. Peltier (Univ. of Delaware, Newark); D. van der Lelie (Brookhaven National Lab); R.L. Chaney (USDA); D.L. Sparks (Univ. of Delaware).

Science of the Total Environment, Vol 367 No 2, p 732-744, 31 Aug 2006

Nickel (Ni)-contaminated soils, a Welland loam and a Quarry muck, from a smelter site in Port Colborne, Canada, were used in greenhouse and bioavailability studies. Treated and untreated with limestone, the soils varied in pH, organic matter content, and total Ni (63 to 22,000 mg/kg). *Alyssum murale*, a hyperaccumulating plant species, and oat (*Avena sativa*), a non-hyperaccumulator, were grown on the soils to estimate Ni accumulation. A Ni-specific bacterial biosensor was used to determine Ni bioavailability, and those results were compared against chemical extraction results. Data from the greenhouse, chemical extraction, and biosensor studies suggested that as soil pH was increased with liming, Ni bioavailability decreased; however, the phytoextraction capability of *A. murale* increased as soil pH increased, though that of *A. sativa* did not. The Ni-specific bacterial biosensor successfully predicted Ni bioavailability in the soils and indicated that higher Ni bioavailabilities occur at pH values of 5.1 and 6.

<http://ag.udel.edu/SoilChem/Everhart06STE.pdf>

#### Assessment of Heavy Metal Mobility in Dredged Sediments: Porewater Analysis, Single and Sequential Extractions

Cappuyns, V., R. Swennen, and J. Verhulst, Katholieke Univ. Leuven, Heverlee, Belgium.

Soil and Sediment Contamination (formerly Journal of Soil Contamination), Vol 15 No 2, p 169-186, Mar/Apr 2006

Dredged sediments deposited on land between 10 and 70 years ago were characterized according to their physico-chemical properties, total metal concentrations, and porewater composition. Actual and potential heavy metal availability was assessed by means of single extractions with calcium chloride, EDTA, or acetic acid, and a modified version of the BCR (Bureau Communautaire de Reference) extraction procedure was adapted to the elevated acid-neutralizing capacity of the sediments and applied. Information on element mobility was assessed and the methodologies were critically evaluated. Cd and Zn were found to be the elements with the highest potential availability, while Cu and Ni displayed a medium availability. The investigators observed that different types of extractions deal with heavy metal mobility in a different way, and the measurement of key factors, such as the pH of the extracts, can be helpful for interpretation of results.

Bedrock Characterization with Seismic Refraction, for Cost-Effective Brownfield Investigation and Remediation: A Case History

Vanderlaan, John and Greg Byer.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Environmental investigation activities at the site of a former bus depot have found that both gasoline and diesel free product have migrated down to the interbedded shale and limestone bedrock aquifer below the site. A seismic refraction geophysical survey was completed to gain a more detailed understanding of the top of bedrock morphology, which is essential to determining the extent of impact and designing the remediation system. Data were analyzed using the generalized reciprocal method and translated into a bedrock elevation map that included a closed depression at the end of a minor valley trending below a suspected source area. The results were used to predict subsurface flow directions and identify potential areas of collected free product.

Benefits of Partial DNAPL Source Removal: Measuring Contaminant Flux Change

Annable, M.D. (Univ. of Florida), K. Hatfield, J. Cho, M.C. Brooks, A.L. Wood, C.G. Enfield, C. Holbert, and K. Gorder.

The Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, (Monterey, CA; May 2006): Book of Abstracts. Battelle Press, Columbus, OH. Poster presentation, 2006

At Hill AFB, two innovative methods for measuring water and contaminant mass flux at a DNAPL site were evaluated after the implementation of surfactant flushing. Ten monitoring wells on approximately 10-ft centers were placed downgradient from the DNAPL source zone. In one technique, a transect of passive flux meters was used to measure TCE mass flux passing through the PFMs before and after the surfactant flood. The meters indicated a reduction in TCE flux of approximately 90%. With the other technique--the integral pumping test method--water was subsequently extracted from the same series of wells, and contaminant concentration/time series was measured in each pumping well effluent. These methods were also compared to mass flux calculated using water quality data from the transect of fully screened wells. The three independent measurement techniques provided comparable results, showing significant contaminant mass flux reduction following remediation.

Calibration of a Passive Sampling Device for Time-Integrated Sampling of Hydrophilic Herbicides in Aquatic Environments

Tran, A.T.K., R.V. Hyne, and P. Doble.

Environmental Toxicology and Chemistry, Vol 26 No 3, p 435-443, Mar 2007

A styrenedivinylbenzene copolymer sorbent modified with sulfonic acid functional groups and embedded in a SDB-RPS Empore(tm) disk was tested as a receiving phase in a passive sampling device for monitoring polar pesticides. The disk was overlaid with either a polysulfone or a polyethersulfone diffusion membrane and applied to the determination of 5 nonionized target herbicides (simazine, atrazine, diuron, clomazone, and metolachlor) and 4 phenoxy acid herbicides (dicamba, triclopyr, (4-chloro-2-methylphenoxy)acetic acid [MCPA],

and (2,4-dichlorophenoxy)acetic acid [2,4-D]) with log octanol/water-partition coefficient values of less than three in water. The SDB-XC Empore disk covered with a polyethersulfone membrane took up more of these herbicides than the disk covered with a polysulfone membrane. Over a period of 21 days, the uptake rate of each herbicide by the sampler was linearly proportional to its concentration in the water, and the sampling rate was independent of the water concentrations over this period.

#### Carbon Nanotubes as a Sensing Material for Chemical Sensors

Li, Jing and Yijiang Lu, Center for Nanotechnology, NASA Ames Research Center, Moffett Field, CA.

209th ECS Meeting, Abstract #1235, Denver, CO, 7-12 May 2006

An interdigitated, electrode-based chemical sensor platform has been developed for highly sensitive detection of chemicals such as NO<sub>2</sub>, NH<sub>3</sub>, CH<sub>4</sub>, Cl<sub>2</sub> and other organic vapors. The detection limit ranges from ppm to ppb concentrations. A carbon nanotube-based sensor array has also been developed for gas detection and discrimination at very low concentration levels. The mechanism of the carbon nanotube sensors was investigated using a 4-point resistive measurement, which revealed that the main sensing signal is from the carbon nanotubes themselves rather than from the carbon nanotube/metal contact. Many real-world applications for the sensors are discussed.

#### Case Studies at Several Environmental Sites Using a Multi-Parameter Borehole Water Quality Investigation Tool

Ursic, James.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

A relatively new and commercially available borehole investigation tool is specifically tailored to operate in monitoring and water wells for the purpose of rapidly assessing various water quality issues. Multiple sensors are applied simultaneously within the tool's housing to monitor pressure (depth), temperature, dissolved oxygen, fluid conductivity, redox, and chloride. One additional sensor can be chosen to monitor one of either ammonia, nitrate pH, sulfides, copper, or iodine. The tool can operate in wells as small as two inches in diameter, and its sensors have rapid response times. The instrument can be trolled down the well at speeds of 15 to 20 feet per minute while collecting and viewing data in real time. All sensors are capable of withstanding pressures of at least 1,500 feet of hydraulic head. The tool can be used to detect anomalous water quality zones and to monitor borehole fluid long term.

## Chamber Evaluation of a Portable GC with Tunable Retention and Microsensor-Array Detection for Indoor Air Quality Monitoring

Lu, C.J., C. Jin, and E.T. Zellers.

Journal of Environmental Monitoring, Vol 8 No 2, p 270-278, Feb 2006

A prototype instrument designed for on-site indoor determinations of VOC mixtures contains a miniature multi-stage preconcentrator, a dual-column separation module with pressure-tunable retention capabilities, and an integrated array of 3 polymer-coated surface acoustic wave sensors. The instrument was tested on a set of 15 common indoor air contaminants at ppb concentrations within a stainless-steel chamber under a range of conditions. The gases were identified reliably at a known level of confidence by combining column retention times with sensor-array response patterns and applying a multivariate statistical test of pattern fidelity for the chromatographically resolved vapors. Limits of detection ranged from 0.2 to 28 ppb at 25 degrees C for 1-L samples collected and analyzed in less than 12 min. Reductions in sensor sensitivities with increasing temperature were predictable and similar among the sensors in the array. Short-term fluctuations in concentration were accurately tracked by the instrument. The authors conclude that this type of instrument could provide routine, semi-autonomous, near real-time, multi-vapor air monitoring.

## Characterization of LNAPL in Fractured Rock

Hardisty, P.E. (Komex, Bristol, UK); H.S. Wheater (Imperial College of Science and Technology, London); D. Birks and J. Dottridge (Komex, Bristol, UK).

Quarterly Journal of Engineering Geology & Hydrogeology, Vol 36 No 4, p 343-354, Nov 2003

Light non-aqueous phase liquids (LNAPLs) behave very differently in fractured rocks than they do in porous media, and differently again than DNAPLs in fractured rocks. Despite this, relatively little is available in the literature on the specific factors governing LNAPL distribution, migration, and behavior in fractured aquifers. Behavior of LNAPL within a fractured rock mass is a function of the properties of the immiscible fluid, the geometry of the fracture network, rock matrix properties, and the groundwater regime. Relatively small volumes of LNAPL within vertical or sub-vertical fractures can produce significant LNAPL pressure heads, resulting in LNAPL penetration into the saturated zone. Penetration can be significantly deeper than predicted by porous medium models. Groundwater surface fluctuations can cause lateral LNAPL migration in directions controlled by the fracture network geometry, rather than the hydraulic gradient. LNAPL on the groundwater surface can be pumped along intersecting fractures as the groundwater surface rises and falls. Vertical and near-vertical fractures play a key role in LNAPL movement and penetration beneath the groundwater surface and so should be a focus of investigation and remedial activity. The implications for characterization and remediation are significant as illustrated by case histories from sites where LNAPL is present in discretely fractured aquifers. Measured thicknesses of LNAPL in wells relate more to the triggering of individual pulse-like flow events, triggered by changes in LNAPL connectivity with the fracture network and changes in the pressure regime, than to equilibria between fluids in the well and the adjacent rock. Accordingly, angled holes can play a key role in detection and collection of LNAPL within near-vertical fractures. The presence of potentially mobile LNAPL well below historical groundwater surface lows should be considered, and groundwater surface fluctuations should be carefully controlled during remediation to avoid triggering lateral migration.

## Characterizing Clutter in the Context of Detecting Weak Gaseous Plumes in Hyperspectral Imagery

Burr, Tom, Bernie Foy, Herb Fry, and Brian McVey, Los Alamos National Laboratory. *Sensors*, Vol 6 No 11, p 1587-1615, Nov 2006

Weak gaseous plume detection in hyperspectral imagery requires that background clutter consisting of a mixture of components--e.g., water, grass, and asphalt--be well characterized. The appropriate characterization depends on analysis goals. Although clutter as a single-component multivariate Gaussian (SCMG) is rarely seen, proposed alternatives such as various mixture distributions might not be necessary for modeling clutter in the context of plume detection when the potentially present chemical targets are known at least approximately. The research goal is to identify the extent to which the generalized least squares (GLS) approach applied to real data to look for evidence of known chemical targets leads to chemical concentration estimates and to chemical probability estimates (arising from repeated application of the GLS approach) that are similar to corresponding estimates arising from simulated SCMG data. In some cases, approximations to decision thresholds or confidence estimates based on assumption that the clutter has a SCMG distribution will not be sufficiently accurate; for these cases, a strategy is described that uses a scene-specific reference distribution to estimate decision thresholds for plume detection and associated confidence measures.

<http://www.mdpi.org/sensors/papers/s6111587.pdf>

## A Chemical Sensor for In Situ Monitoring of Chlorinated Compounds

Campbell, D.P. and D.S. Gottfried, Georgia Tech Research Inst., Atlanta.

The Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, (Monterey, CA; May 2006): Book of Abstracts. Battelle Press, Columbus, OH. Poster presentation, 2006

The Georgia Tech Research Institute has developed a chemical sensor capable of detecting a wide variety of chemical and biological species in groundwater. The sensor is small, fast, highly sensitive, and reusable, and provides a real-time direct measurement with no additional steps or consumable reagents. Many of the sensor's components are inexpensive and off the shelf. At the heart of the device is a planar optical waveguide interferometer that has an evanescent field sensitive to index of refraction changes in the volume immediately above (up to .5 microns) the surface. Placing a chemically sensitive polymer film within this region provides the basis for the sensor response. Polymer films have been selected that are responsive to chlorinated compounds, especially TCE, PCE, and the daughter products. Laboratory data show detection limits in the low ug/L (ppb) for most of these compounds in water. An array of polymer films on a multi-channel sensor enables identification and quantitation of the chlorinated analytes in the sample. The sensor components can be packaged either for use at the well head with grab samples or for down-well, in situ monitoring.

Clustering to Improve Matched Filter Detection of Weak Gas Plumes in Hyperspectral Thermal Imagery: Analysis of Hyperspectral Image Data

Funk, Christopher; James Theiler; Dar Roberts; Christoph Borel.

IEEE Transactions on Geoscience and Remote Sensing, Vol 39 No 7, p 1410-1420, 2001

The authors describe the use of modified k-means clustering to improve matched filter performance, examine several simple bivariate cases in detail, and discuss the interaction of filtering and partitioning. The traditional k-means algorithm was modified to work with a sample of the image at each iteration and tested against two hyperspectral datasets. A new extreme centroid initialization technique was introduced to speed convergence. The comparison of several matched filtering formulations--the simple matched filter, the clutter matched filter, and the saturated matched filter--for various classes and synthetic hyperspectral images, performance of the various clutter matched filter formulations was similar, with all about an order of magnitude better than the simple matched filter. Clustering in conjunction with clutter matched filtering can improve fifty-fold over the simple case, enabling detection of very weak signals in hyperspectral images.

Collection and Analysis of Hexavalent Chromium in Ambient Air

Swift, J., M. Howell, and D. Tedder, Eastern Research Group, Morrisville, NC.

NEMC 2006: The 22nd Annual National Environmental Monitoring Conference, Arlington, Virginia, 28-31 August 2006

U.S. EPA worked in conjunction with Eastern Research Group to improve the California Air Resource Board Method 039 for Cr(VI) monitoring. Attempts to sample and analyze Cr(VI) with improved sensitivity uncovered challenges in the sampling procedures. Issues with background contamination on filters and stability of field samples were the most important contributors to bias and imprecision. Different filters and filter preparations were studied to minimize background Cr(VI) on filters. A standardized method for media preparation and storage is discussed. A stability study was performed to determine the best storage conditions to maintain Cr(VI) stability with less than 30 relative percent difference. Stability was also evaluated using co-located samplers with spiked and blank filters. Data obtained using improvements to the Cr(VI) sampling and analysis procedure will be presented to show the recent history of Cr(VI) recovery from field samples.

<http://nemc.us/proceedings/2006/06T18pa.pdf>

The Commercialization of Method 6800: Speciated Isotope Dilution Mass Spectrometry for the Determination of Hexavalent Chromium

Vicinie, Albert F. III, Mark Bruce, and William Reinheimer, Severn Trent Laboratories, Inc.

NEMC 2006: The 22nd Annual National Environmental Monitoring Conference, Arlington, Virginia, 28-31 August 2006

Method 6800 has recently been approved for the determination of the various species of metals, such as chromium(III) and Cr(VI). It is a hyphenated technique that couples ion chromatography (IC) with Inductively Coupled Plasma/Mass Spectrometry (ICP/MS). To date, this method has been used primarily in academia and with limited project support. The method offers two primary challenges. (1) It utilizes a mathematical approach to deconvolute the species that is unique to other traditional methods utilized in commercial environmental methods. (2)



The method does not specify in detail quality control practices and deliverables to be performed and provided to allow the data user to effectively evaluate the data set. This paper identifies the primary differences in this method from traditional as well as proposed QA/QC practices, along with a deliverable to allow effective data validation and assessment.

<http://nemc.us/proceedings/2006/06T47pa.pdf>

Comparison of Sampling Methods for Determination of Redox Zonation and Natural Attenuation of Chlorinated Solvents in a Wetland, Aberdeen Proving Ground, MD

Dyer, L.J. (USGS, Reston, VA); M.M. Lorah (USGS, Baltimore, MD); D.R. Burris (Integrated Science & Technology, Panama City, FL).

Geological Society of America Annual Meeting, Denver, Colorado, 27-30 October 2002

As part of a study of natural attenuation of chlorinated solvents discharging to a freshwater tidal wetland, porewater concentrations of volatile organic compounds (VOCs), iron, sulfide, and methane were compared at six sites using four different sampling methods at comparable depths. The sampling methods included (1) 1.9-cm-diameter drive-point piezometers, (2) 0.64-cm-diameter tubing samplers with inverted screens at the bottom, (3) multilevel samplers that contain seven 1-cm-diameter screened intervals in one borehole, and (4) porous-membrane diffusion samplers (peepers). Peepers offered the most reliable results and gave the best overall indication of porewater chemistry. Samples from the peepers generally showed higher concentrations of VOCs and sulfide than samples from the other three devices at the same depths. Methane concentrations in the peepers and multilevel samplers showed fairly good agreement. The lowest concentrations of these three constituents were found in the piezometers; however, the piezometers were generally consistent with the other devices in reduced iron concentrations. The higher concentrations of most constituents in the peepers may be attributed to the lower chance of sample aeration and volatilization because samples are passively collected, tubing insertion for sample withdrawal is unnecessary, and samples do not have to be pulled from depth as in the other devices. Because of their fine sampling resolution, the peepers generally showed clearer trends in redox zonation and distribution of VOC metabolites than the other sampling devices, thus providing more detailed evidence of the occurrence of natural attenuation in the wetland porewater.

Conductivity Profile Rate of Change from Field and Laboratory Data within Biodegrading Petroleum Hydrocarbon

Werkema, D.D., E.A. Atekwana, and E.A. Atekwana.

SAGEEP 2006: Symposium on the Application of Geophysics to Environmental and Engineering Problems, 2-6 April 2006, Bellevue, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. [slide presentation] Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

In a field and lab experiment of long-term (500 days) measurements, the objective was to determine the rate of change in bulk conductivity and whether this rate of change correlated with petroleum hydrocarbon degradation. In the field, bulk conductivity was obtained monthly from vertical probes installed at a hydrocarbon contaminated site undergoing biodegradation. In the lab, conductivity measurements were made in sand columns simulating the biodegradation of diesel fuel. In general, both the field and laboratory results show increasing bulk conductivity

over time from depth zones impacted with petroleum hydrocarbon contamination. The highest increase was observed above the water table where hydrocarbon contamination was in residual and free phase (petroleum smear zone). The temporal bulk conductivity change in the contaminated sediments and the uncontaminated sediments was fitted to an exponential model and then the two were subtracted, resulting in the bulk conductivity rate of change due to the presence of petroleum hydrocarbons. The highest rate constant was 0.0061 per day for the field data and 0.0023 per day for the laboratory sand columns. The laboratory data showed a broad conductivity rate increase occurring stratigraphically coincident with the hydrocarbon contamination in the free and residual phase above the saturated zone. The field data showed a general increasing rate of conductivity change within the zone, but also included zones of decreasing change. This is interpreted in part to a dynamic water table and the development of a hydrocarbon smear zone which contains a variable air/water/LNAPL mixture. The petroleum hydrocarbon degradation rate of 0.0539 per day was determined for sediments in the saturated zone and 0.107 for sediment in the unsaturated zone. These values are consistent with higher bulk conductivity rates of change in the unsaturated zone, except these rates are increasing versus decreasing for the LNAPL concentration rate of change. The bulk conductivity results suggest that the greatest rate of change occurred stratigraphically within hydrocarbon contaminated zones, and the magnitude of the rate of change is much less than the magnitude of the hydrocarbon degradation rate. Within the hydrocarbon-impacted zone, the data reveal an inverse relationship with the hydrocarbon concentration rate of change.

Cone-Based Geophysical Imaging: A Proposed Solution to a Challenging Problem  
Knight, Rosemary and Adam Pidlisecky  
The Leading Edge, Vol 24 No 1, p 34-38, Jan 2005

During characterization of a contaminated site, measurements are made that allow for the development of an accurate model of the physical, chemical, biological, and hydrogeological properties of the subsurface. A good model will support the design of an appropriate plan for remediating the contaminated site and can also be used, and continually updated, for short- or long-term monitoring of the site. Site characterization can involve locating and identifying a known or suspected contaminant, and can also involve determining the properties of the subsurface controlling the fate and transport of the contaminant. "Cone geophysics" is a new word for a new area of research where researchers are developing ways of using cone penetrometers to obtain geophysical data from the upper 100 m of the earth. Cone penetrometers are commonly used in engineering studies and are pushed into the earth, making a measurement that is considered to be "minimally invasive." Various methods of conducting geophysical surveys are being examined; these methods usually require the drilling of boreholes using the cones. The data typically collected with cones can help with the inversion and interpretation of near-surface geophysical data.

[http://pangea.stanford.edu/research/enviro/papers/Knight%20and%20Pidlisecky%20\(2005\).pdf](http://pangea.stanford.edu/research/enviro/papers/Knight%20and%20Pidlisecky%20(2005).pdf)

## Contaminated Site Mapping Using GPR and Electrical Resistivity in Brazil

Carvalho, Debora and Roberto Okabe.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

In an operating railroad yard in Brazil, fuel supply and maintenance areas for train engines and vehicles presented hydrocarbon contamination, including light nonaqueous phase liquids. Multifrequency GPR equipment was used to survey the area. The geophysical results reach around 20 meters deep. The investigators noted that water percolation might help to spread the contamination through the depths. Hydrocarbon-contaminated sites usually present low resistivity anomalies and attenuation of electromagnetic signals. All geophysical, geological, and borehole information was integrated to determine the next steps for investigation and site remediation. Integrated characterization by these methods allows delineation of the contaminant plume and indicates likely areas for direct future investigation.

Copper Selective Electrode Based on 1,8-bis(2-Hydroxynaphthaldiminato)3,6-Dioxaoctane  
Ardakani, M.M. (Yazd Univ., Yazd, Iran); S.H. Mirhoseini and M. Salavati-Niasari (Kashan Univ., Kashan, Iran).

Acta Chimica Slovenica, Vol 53 No 2, p 197-203, 2006

An ion-selective electrode of coated wire was developed using 1,8-bis(2-hydroxynaphthaldiminato)3,6-dioxaoctane as carrier for selective and sensitive detection of copper (Cu[II]) ions. The electrode exhibits a good potentiometric response for Cu(II) over a wide concentration range ( $3.3 \times 10^{-6}$ -1.0 M) with a slope  $29.0 \pm 0.5$  mV/decade. The electrode has a response time between 10 to 15 seconds in aqueous solutions ranging in pH from 4.0 to 8.0. This paper reports applications of the proposed electrode to the determination of copper in real samples and as an indicator electrode for potentiometric titration of Cu(2+) ion with EDTA.

<http://acta.chem-soc.si/53/53-2-197.pdf>

## Coupled Geophysical-Hydrological Modeling of a Controlled NAPL Spill

Kowalsky, M., E. Majer, J. Peterson, S. Fensterle, and A. Mazzella.

Eos Transaction of the AGU, Vol 87 No 52, Fall Meet. Suppl., Abstract H43G-02, 2006

Large-scale laboratory experiments were conducted over a period of several years to evaluate the use of various geophysical methods--ground-penetrating radar (GPR) and seismic and electrical methods--for monitoring controlled spills of tetrachloroethene (PCE). The authors discuss a study in which PCE was introduced into a large sand tank containing a heterogeneous distribution of sand and clay mixtures and allowed to migrate while time-lapse geophysical data were collected. NAPL migration was simulated using TOUGH2, the multiphase multicomponent flow simulator with a 2-D radial model that takes advantage of radial symmetry in the experimental setup. The flow model was coupled to forward models for simulating the GPR and seismic measurements, and joint inversion of the multiple data types results in time-varying NAPL saturation distributions. Comparison of the two approaches with results of the post-experiment excavation indicate that combining geophysical data types and incorporating

hydrogeological constraints improves estimates of NAPL saturation relative to the conventional interpretation of the geophysical data sets.

#### A Coupled Hydrogeological-Petrophysical Analysis of Geophysical Variations in the Vadose Zone

Mickle, James, Anthony Endres, and Estella Atekwana.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

High-resolution geophysical data were acquired during a controlled LNAPL release experiment in 1993 in which kerosene was injected into a large-scale test cell containing repacked Borden sand. Vertical profiles were obtained using neutron moisture logging, a vertical resistivity probe (VRP), and a time domain reflectometry (TDR) array. Pre-release water content profiles as determined from the geophysical data were compared with laboratory saturation-capillary pressure measurements. The neutron moisture profile provided a good fit to the lab data, but significant differences were observed between both the VRP- and TDR-derived profiles and the lab data. The use of several models and analysis of the results indicated that the inference of water content from geoelectrical probes requires more study, especially whether standard petrophysical relationships accurately represent the dependence of geoelectrical properties on water content under vadose zone conditions.

#### Design and Field Application of an Automated Cartridge Sampler for VOC Concentration and Flux Measurements

Kuhn, U., T. Dindorf, C. Ammann, S. Rottenberger, P. Guyon, R. Holzinger, S. Ausma, T. Kenntner, F. Helleis, and J. Kesselmeier.

Journal of Environmental Monitoring, Vol 7 No 6, p 568-576, June 2005

This paper describes the design of a constant flow sampler for volatile organic compounds (VOCs) that can be used for fully automated concentration and flux measurements. The sampler incorporates a microprocessor control unit, and sampling sequences can be programmed directly or by remote control through a PC. All important operational parameters necessary for a complete sampling audit trail are logged. Inner wetted surfaces of the sampler are constructed from non-contaminating materials that do not sorb or emit VOCs, thus permitting the collection of representative samples even at very low VOC concentrations. Actual field applications include airplane profile measurements above a tropical rainforest area, as well as gradient and relaxed eddy accumulation (REA) measurements over a mid-latitude mixed forest stand. This paper emphasizes the application of the VOC sampler as an integrated part of a REA system.

## Detecting and Quantifying Reductive Dechlorination During Monitored Natural Attenuation at the Savannah River CBRP Site

Istok, J.D. and J.A. Field (Oregon State Univ.); E. Raes (Engineering and Land Planning Associates); M.R. Millings (Savannah River National Lab); A.D. Peacock (Microbial Insights, Inc.).

Report No: WSRC-STI-2006-00340, 50 pp, Jan 2007

Researchers used field sampling and testing in 10 monitoring wells to investigate the relationship between baseline geochemical and microbial community data and in situ reductive dechlorination rates at a site contaminated with trichloroethene (TCE) and carbon tetrachloride (CTET). The 10 monitoring wells represented conditions along a ground-water flow path from the contaminant source zone to a wetlands ground-water discharge zone. Analytical results from background ground-water samples for a suite of geochemical and microbial parameters and the results of push-pull tests with fluorinated reactive tracers were used to measure in situ reductive dechlorination rates. Geochemical data provided some evidence of the occurrence of reductive dechlorination at the site, and microbial data confirmed the presence of known dechlorinating organisms, as well as sulfate reducers, iron reducers, and methanogens. A principal component analysis identified three groups of wells with similar geochemical and microbial characteristics. Push-pull tests were conducted using trichlorofluoroethene (TCFE) as a reactive tracer for TCE and trichlorofluoromethane (TCFM) as a reactive tracer for CTET. Injected TCFE was transformed in situ to cis- and trans-dichlorofluoroethene and chlorofluoroethene. In one test, TCFE completely dechlorinated to fluoroethene. Injected TCFM was transformed in situ to dichlorofluoromethane and chlorofluoromethane. Zero-order TCFE transformation rates ranged from  $< 0.05$  to  $1.00$  nM/hr ( $< 0.44$  to  $8.76$  uM/yr). TCFE reduction rates differed among the three groups of wells identified by principal component analysis, providing preliminary evidence that geochemical, microbiological, and in situ reductive dechlorination rates may provide complementary information. A single TCFM transformation rate was estimated as  $< 0.05$  nM/hr ( $0.44$  uM/yr). This study demonstrated that push-pull tests with reactive tracers can be used to detect and quantify reductive dechlorination of chlorinated ethenes and methanes under monitored natural attenuation conditions.

[http://www.osti.gov/bridge/product.biblio.jsp?query\\_id=8&page=0&osti\\_id=897536](http://www.osti.gov/bridge/product.biblio.jsp?query_id=8&page=0&osti_id=897536)

## Detecting Microbial Growth and Metabolism in Geologic Media with Complex Conductivity Measurements

Davis, C.A., E.A. Atekwana, and E.A. Atekwana (Univ. of Missouri-Rolla); L.D. Slater (Rutgers Univ. Newark, NJ); P.M. Bottrell and L.E. Chasten (Univ. of Missouri-Rolla); J.D. Heidenreich (Purdue Univ., West Lafayette, IN).

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS41A-03, 2006

Complex conductivity measurements between 0.1-1,000 Hz were taken in biostimulated sand-packed columns to investigate microbial growth, biofilm formation, and microbial metabolism on the electrical properties of porous media. Microbial growth and metabolism was verified by environmental scanning electron microscope imaging, pH changes, and direct microbial counts. Based on the results, the authors conclude that complex conductivity techniques are feasible for detecting microbial growth (imaginary conductivity measurements) and metabolism (real conductivity measurements) with implications for bioremediation monitoring.

### Delineation of Water Inflow in an Underground Potash Mine with 3-D Electrical Resistivity Imaging

Eso, R., M. Maxwell, D. Oldenburg, and J. Unrau.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

In a potash mine, the combination of highly resistive dry salt and highly conductive wet salt makes water inflow areas good candidates for electrical resistivity imaging (ERI), which is also known as electrical resistivity tomography. Because of the 3-D distribution of current and potential electrodes and the 3-D nature of the targets, full 3-D forward modeling and inversion of the data are required. The nature of underground mining limits the placement of electrodes to existing underground drifts, which restricts the available electrode geometry. By placing additional electrodes in boreholes, an electrode geometry with enough information to constrain the 3-D inversion can be deployed. A case study is presented of the delineation of a water inflow in a potash mine using 3-D ERI.

[http://www.eos.ubc.ca/~reso/robeso\\_152.pdf](http://www.eos.ubc.ca/~reso/robeso_152.pdf)

### Detection and Identification of Toxic Air Pollutants Using Field Portable and Airborne Remote Imaging Systems

Williams, D.J., B.L. Feldman, A.N. Pilant, R.B. Hammat, M. Sather, P.G. Lucey, D. Furry, L.D. Worthy, and J.G. Lyon.

Air & Waste Management Association: Proceedings, New Orleans, LA, 20-23 June 2006

Remote sensing technologies are a class of instrument and sensor systems that include laser imageries, imaging spectrometers, and visible to thermal infrared cameras. These systems have been used successfully for gas-phase chemical compound identification in a variety of field environments. Remote sensing and imaging technologies provide a tool to quickly identify the source of high leaking components by allowing the user to rapidly detect emissions, in some cases in real time. These capabilities allow an investigator to scan large areas containing tens to hundreds of potential leaks relatively quickly. Imaging spectrometers and cameras can be deployed on fixed-wing or helicopter platforms, which allows for emission monitoring over large areas. Some instruments are very portable and lend themselves to more detailed ground investigations of smaller areas.

### Detection and Quantification of Gases in Industrial-Stack Plumes Using Thermal-Infrared Hyperspectral Imaging

Young, S.

The Aerospace Corporation, El Segundo, CA. Tech. Rep. ATR-2002(8407)-1, 80 pp, 2002

Measurements of effluent gases in the plumes of hot emissions stacks were collected at a refinery using the SEBASS (spatially enhanced broadband array spectrograph system) thermal-infrared hyperspectral imaging sensor. A method was formulated to extract gas column density and plume temperature from the gas contrast radiance. The method employs a spatial degradation

of the data to circumvent the indeterminacy inherent to the problem. Concentration values for water vapor, carbon dioxide, ammonia, nitrogen dioxide, sulfur dioxide, ethylene, and methane are discussed.

<http://www.cis.rit.edu/~cnspci/references/pdf/YOUNGATR-2002.pdf>

#### Determination of Mercury in Aqueous and Geologic Materials by Continuous Flow/Cold Vapor/Atomic Fluorescence Spectrometry (CVAFS)

Hageman, Philip L.

U.S. Geological Survey Techniques and Methods 5-D2, 13 pp, 2007

New methods for the determination of total mercury in geologic materials and dissolved mercury in aqueous samples have been developed that eliminate the use of sodium dichromate ( $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ ) as an oxidizer and preservative and significantly lower the detection limit for geologic and aqueous samples. The new methods also update instrumentation from the traditional use of cold vapor/atomic absorption spectrometry to cold vapor/atomic fluorescence spectrometry. At the same time, the new digestion procedures for geologic materials use the same size test tubes and the same aluminum heating block and hot plate as required by the current methods. New procedures for collecting and processing of aqueous samples use the same procedures that are in use in 2006, except that the samples are now preserved with concentrated hydrochloric acid/bromine monochloride instead of sodium dichromate/nitric acid. Both the "old" and new methods have the same analyst productivity rates. These similarities should permit easy migration to the new methods. Analysis of geologic and aqueous reference standards using the new methods show that these procedures provide mercury recoveries that are as good as or better than the previously used methods.

<http://pubs.usgs.gov/tm/2007/05D02/>

#### Determination of Organophosphorus Compounds by GC-ICPMS

Rosal, C. G., G. Momplaisir, and E. M. Heithmar.

2006 Winter Conference on Plasma Spectrochemistry, Tucson, AZ, January 8-14, 2006

The most widely used technique to determine organophosphorus (OP) compounds is gas chromatography-mass spectrometry (GC-MS), which can be adversely affected by concomitants that mask the OP mass spectra. EPA's National Exposure Research Laboratory in Las Vegas is investigating alternatives to conventional extraction and analytical methods. Vacuum distillation (VD) is a technique developed at EPA Las Vegas that rapidly extracts both volatile and semivolatile analytes from a wide range of matrices and injects them into an on-line GC. ICPMS can provide sensitive, multi-elemental detection of phosphorus and other heteroatoms found in OP pesticides and CWAs. EPA is currently investigating the application of VD-GC-ICPMS for the analysis of environmental samples for OP pesticides and chemical warfare agents. This presentation discusses preliminary results of the first phase of the project for developing and evaluating the GC-ICPMS method.

Development and Application of a Laboratory Flux Measurement System (LFMS) for the Investigation of the Kinetics of Mercury Emissions from Soils  
Bahlmann, E. and R. Ebinghaus (GKSS Research Centre Geesthacht, Germany); W. Ruck (Univ. of Lueneburg, Lueneburg, Germany).  
Journal of Environmental Management, Vol 81 No 2, p 114-125, Oct 2006

A laboratory flux measurement system (LFMS) has been developed to study the effect of major environmental variables on the emission of mercury under controlled conditions, examining the effects of turbulent mixing, soil temperature, and solar radiation on the emission of mercury from soils. The emission of mercury from soils was constant over time under constant experimental conditions. Light-induced flux was found to be independent of the soil temperature and showed a strong spectral response to UV-B.

<http://www.aseanenvironment.info/Abstract/41013652.pdf>

Development and Application of Immunoaffinity Column Chromatography as a Cleanup Method for the Determination of Atrazine in Complex Environmental Sample Media  
Chuang, J.C., J.M. Van Emon, R. Jones, J. Durnford, and B. Lordo.  
Analytica Chimica Acta, Vol 583 No 1, p 32-39, 2007

The authors describe the development and evaluation of a rabbit antibody immunoaffinity (IA) column procedure as a cleanup method for the determination of atrazine in soil, sediment, and food. Four IA columns were prepared by immobilizing a polyclonal rabbit anti-atrazine antibody solution to HiTrap Sepharose columns. The four IA columns showed reproducible coupling efficiency for the immobilization of the atrazine antibody and consistent binding and releasing of atrazine. Challenged with real-world soil, sediment, and duplicate-diet food samples, the IA columns effectively removed interferences from these various matrices for subsequent gas chromatography/mass spectrometry and ELISA analysis. The IA column cleanup procedure coupled with ELISA analysis could be used as an alternative effective analytical method for the determination of atrazine in complex sample media such as soil, sediment, and food samples.

Development of a Field Method for Identification of Acid-Generating Mining Wastes Using Portable XRF Technology  
Bell, K. and T. McComb (Barge, Waggoner, Sumner and Cannon, Inc., Nashville, TN); F. Miller (Glenn Springs Holdings, Inc., Lexington, KY); M. Bowers (Secaps Environmental, Inc., Fuquay-Varina, NC). 2007 SME Annual Meeting & Exhibit and 109th National Western Mining Conference, February 25-28, 2007, Denver, Colorado. Society for Mining, Metallurgy, and Exploration, Abstracts.

Acid-base accounting (ABA) is the conventional, expensive, and time-consuming method of estimating the acid-generating potential (AGP) of mining materials. To enable rapid decision making during phased remedial actions at the Copper Basin Mining District site, a field method based on the site-specific relationship between sulfur and AGP was developed to identify acid-generating materials. Emerging portable x-ray fluorescence technology was used to measure sulfur in the field for real-time identification of acid-generating materials, thus minimizing sample collection and analysis and allowing rapid, on-site decisions on removal of materials.



### The Development of Cryoprobe Nuclear Magnetic Resonance Spectroscopy for the Rapid Detection of Organic Contaminants in Potable Water

Charlton, A.J., J.A. Donarski, S.A. Jones, B.D. May, and K.C. Thompson.

Journal of Environmental Monitoring, Vol 8 No 11, p 1106-1110, Nov 2006

The authors describe the detection of trace levels of a range of organic contaminants--pesticides, toxins, and an explosive--in potable water, using cryoprobe NMR spectroscopy with limited sample preparation and rapid acquisition times. NMR spectroscopy is applicable for use in emergency scenarios due to the unbiased nature of the technique, which facilitates the detection and characterization of unknown compounds at levels as low as 50 ug/L.

### Development of Extraction Tests for Determining the Bioavailability of Metals in Soil (Final Report Draft)

Strategic Environmental Research and Development Program (SERDP), Project CU-1165, 132 pp, Apr 2005

The research conducted under this project is designed to yield a database that establishes whether site- or soil-specific factors affect the bioavailability of target metals from soils. Where the database (from in vivo research) identifies that these types of factors are operating, an additional goal of the research has been to develop simple extraction tests that are inexpensive to perform and that are predictive of metals bioavailability from soil. These tools can then be available to DoD personnel for site-specific evaluation of metals bioavailability from soil at field sites and will result in more accurate exposure and risk estimates that are still protective of human health and the environment. Exposure pathways and receptors of concern were established to target the in vivo research, and focused on three distinct areas: oral bioavailability to humans, dermal bioavailability to humans, and oral bioavailability to wildlife. The project was so designed because each of these receptor/pathway combinations requires a different approach due to the differences in the mechanism of absorption and/or differences in risk assessment methods. The research was undertaken in three phases. First, research was conducted to understand which metals are risk drivers at DoD sites. Second, in vivo testing was conducted on soils to understand whether there are site- or soil-specific parameters that control absorption, and if so, to generate a database of information upon which to base development and validation of in vitro approaches to assessing bioavailability. The third phase, conducted once the in vivo data were compiled, involved determining whether in vitro methods for approximating bioavailability can be supported.

<http://docs.serdp-estcp.org/viewfile.cfm?Doc=ER%5F1165%5FFR%2Epdf>

### Development of Microfluidic/Nanofluidic Sensors Using Catalytic DNA for Heavy Metal Detection

Wang, X., P.W. Bohn, and J.V. Sweedler (Univ. of Illinois, Urbana-Champaign); D.M. Cropek (U.S. Army Construction and Engineering Research Lab).

Pittcon 2006, 12-17 March, Orlando, Florida. Abstract 2140-24.

A Pb(II)-specific, amine-modified DNAzyme fluorescent sensor was immobilized on a UV-activated poly(methylmethacrylate) (PMMA) surface to develop a reliable and sensitive device for in situ measurement of heavy metals. The immobilized DNAzyme was hybridized with its complementary DNA substrate strand containing a quencher. This DNAzyme-laden

PMMA was assembled within a microfluidic/nanofluidic hybrid multilayer device that contains a nanoscale fluidic molecular gate consisting of a thin polycarbonate membrane with nanometer-sized perforations. The molecular gate can further manipulate fluid flows and perform molecular separations on tiny volumes of material. As Pb(II) is transported to the DNAzyme, a fluorescent signal is detected upon cleavage of the substrate strand. This device is an important step toward detecting multiple heavy metal ions with a single injection.

Development of Simple and Sensitive Spectrophotometric Method for the Determination of Bendiocarb in its Formulations and Environmental Samples  
Kumar, K.S., K. Suvadhan, D. Rekha, K. Kiran, B. Jayaraj, K. Janardhanam, and P. Chiranjeevi, S.V. Univ., Tiruapti, A.P., India.  
Environmental Monitoring and Assessment, Vol 127 No 1-3, p 67-72, Apr 2007

An easy, selective, and sensitive spectrophotometric method for the determination of the bendiocarb with prepared reagents in water, vegetation, and soil samples is based on alkaline hydrolysis of the pesticide. The resultant hydrolysis product of bendiocarb was coupled with 2,6-dibromo-4-methylaniline, producing a yellow-colored product. The formation of colored derivatives with the coupling agents is instantaneous and stable for 18 h, 30 h, and 12 h.

Dialysis Sampler Evaluation of Rhizosphere Phytoremediation Processes in the Poplar Grove at J-Field, Aberdeen Proving Ground, Maryland  
Pardue, J.H., W.A. Jackson, and L.E. Martino.  
Argonne National Laboratory, 66 pp, July 2001

This study reports on the first high-resolution dialysis sampling data collected from the root zone of poplar trees used for phytoremediation at J-Field, Aberdeen Proving Ground, MD. As an improved method of monitoring performance of phytoremediation, two dialysis samplers were designed and constructed for the J-Field application. One sampler was installed in the rhizosphere of one of the existing phytoremediation trees (#55), and the other was installed in a control location outside of the phytoremediation grove. The design of the samplers was based on the dialysis sampling approach. Depressions, or cells, were drilled in a solid Plexiglas rod. Deionized water was placed in the cells, which were then covered with a membrane filter sheet (0.2 mm). The samplers were designed to allow insertion into the subsurface using direct push technology. After insertion, constituents in the groundwater diffused across the membrane into the dialysis sampler well. After a period of equilibration, the samplers were retrieved, and the water in the sampler well was sampled and analyzed. Because the sampler can be constructed to any specification, the resolution or spacing of the samples can be specified in the design. The dialysis sampler monitoring results suggest that the impact of the rhizosphere on the chlorinated VOCs is spatially variable and is best studied on the measurement scale employed in this investigation. The initial measurements using this sampling technique suggest that the rhizosphere of tree 55 is a less reducing environment. The results represent only one tree, with possibly an underdeveloped root system relative to other trees in the grove. Further studies should utilize this measurement technique to assess spatial changes in chlorinated VOCs as groundwater moves through the entire grove.

[http://web.ead.anl.gov/jfield/phyto/docs/Dialysis\\_2001.pdf](http://web.ead.anl.gov/jfield/phyto/docs/Dialysis_2001.pdf)

Effect of Microbial Metabolic Byproducts on Electrical Properties of Unconsolidated Sediments  
Aal, Gamal Abdel, Caroline Davis, and Estella Atekwana.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

In an investigation of the effect of metabolic byproducts of microbial activity (e.g., organic acids and biosurfactants) on low-frequency electrical properties of unconsolidated sediments, uniform sand samples were saturated with different concentrations of individual organic acids--acetic, butyric, lactic, and propionic acids--and electrical measurements were obtained in the frequency range 0.1 to 1000 Hz. After repetition of the procedure with different concentrations of natural ionic biosurfactant, it was noted that the electrolytic and interfacial electrical properties of unconsolidated sands increased with increasing concentrations of organic acids, as well as with the biosurfactants. A significant increase in the interfacial electrical properties of biosurfactant at concentrations greater than the critical micelle concentration (CMC) indicated polarization above the CMC. The authors conclude that metabolic byproducts of microbial activity can directly affect the electrical properties of unconsolidated sediments.

Effect of Sampling Method on Measured Porewater Concentrations in a Wetland Contaminated by Chlorinated Solvents

Dyer, Linda Jo, M.M. Lorah, and D.R. Burris.

Proceedings of the Second International Conference on Wetlands & Remediation, September 5-6, 2001, Burlington, Vermont. Battelle Press, Columbus, OH, p 33-40, 2002

Abstract not available.

Effects of Polycyclic Aromatic Hydrocarbon of SAM-Coated Electrodes Using Ferricyanide as the Redox Indicator

Luo, N., D.W. Hatchett, And K.R. Rogers.

American Chemical Society Meeting and Exposition, Washington, DC, August 28 - September 01, 2005

Electrochemical responses on self-assembled monolayer (SAM)-coated polycrystalline gold electrodes were investigated using cyclic voltammetry and square-wave voltammetry with a three-electrode system. Experimental results show potential in the application of pyrene-imprinted SAMs for sensors of polycyclic aromatic hydrocarbons.

Electrical Imaging (Tomography) Studies on the Solid Waste Landfills Sites at Ambasamudram, Tamilnadu, India.

Ramanujam, N., Antony Ravindran, and K. Nathakiri Murugan.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Solid hazardous wastes from a textile mill were dumped at an unlined site near Ambasamudram, Tamilnadu, India, over a period of 15 years. Two-dimensional electrical imaging using a CRM-500 resistivity meter was conducted. Nine profiles ranging from 120 to

195 m in length to 15 to 20 m in depth divide the landfill area and its environs into three broad zones designated low, intermediate, and high. The zone of low resistivity (5.72 ohm-m mean value) is interpreted as solid waste disposal, soil, and fault zones permeated with leachate. The intermediate zone (66.4 ohm-m mean value) is considered an area of weathering, while the unaltered basement rock averages 266.49 ohm-m. Iron and manganese content in the hazardous wastes and leachate enhances high electrical conductivity, which reveals low resistivity.

Electrical Resistivity Surveys in Prospect Gulch, San Juan County, Colorado  
McDougal, Robert R.

U.S. Geological Survey Open-File Report 2006-1171, 38 pp, 2006

Prospect Gulch is a major source of naturally occurring and mining related metals to Cement Creek, a tributary of the upper Animas River in southwestern Colorado. Efforts to improve water quality in the watershed have focused on Prospect Gulch because many of its abandoned mines are located on federal lands. Information on sources and pathways of metals and related groundwater flow will be useful to help prioritize and develop remediation strategies. The occurrence of sulfate, aluminum, iron, zinc and other metals associated with historical mining and the natural weathering of pyritic rock is substantial. In this study, direct current resistivity surveys were conducted to determine the subsurface resistivity distribution and to identify faults and fractures that may act as groundwater conduits or barriers to flow. Five lines of resistivity data were collected in the vicinity of Prospect Gulch, and cross-section profiles were constructed from the field data using a 2-D inversion algorithm. The conductive anomalies in the profiles are most likely caused by wet or saturated rocks and sediments, clay-rich deposits, or high TDS groundwater. Resistive anomalies are likely bedrock, dry surficial and subsurface deposits, or deposits of ferricrete.

<http://pubs.usgs.gov/of/2006/1171/>

Electrochemical Synthesis of Mn/2,4-Dichlorophenoxyacetic Acid Electrodes: An Ion Selective Electrodes for Pesticides

Hatchett, D.W. (Univ. of Nevada, Las Vegas); H.H. Weetall (U.S. EPA); B.L. Bennett (Univ. of Nevada); K.R. Rodgers (U.S. EPA).

209th ECS Meeting, Abstract #1251, Denver, CO, 7-12 May 2006

The electrochemical synthesis of Au/MnOx and MnOx/ 2,4-dichlorophenoxyacetic acid (2,4-D) complex electrodes can be performed in a solution containing both Mn(II) and 2,4-D or by sequential reaction with Mn(II) followed by 2,4-D. Both processes yield a complex electrode with identical chemical properties and reactivity. SEM, FTIR, and electronic spectroscopy were used to characterize the membrane formed. Preliminary potentiometric measurements of the complex electrode in contact with increasing concentrations of 2,4-D yields a linear response with a slope of 54.2 +/- 2.3 mV. An ion-selective electrode mechanism for the membrane is discussed.

## Electron Affinities of Polynuclear Aromatic Hydrocarbons and Chlorinated Hydrocarbons and Their Analysis by Negative Ion Chemical Ionization Mass Spectrometry

Betowski, L.D., M. Enlow, and D.H. Aue.

Proceedings of the 54th American Society for Mass Spectrometry Conference on Mass Spectrometry, Seattle, WA, 28 May - 1 June 2006

Negative-ion chemical ionization mass spectrometry (NICI-MS) is a specific and sensitive technique for monitoring the presence of electron-capturing compounds in the environment. NICI-MS and the electron-capture detector both rely on the electron-capture process, but NICI-MS has an extra dimension of mass selectivity. The major electron-capture product can be either the molecular anion or a fragmentation product. Computational chemistry has the potential to help predict the electron-capture sensitivity by predicting the electron affinity and the mass of the ion product by calculating the most stable ion structure.

## Environmental Whole-Genome Amplification to Access Microbial Populations in Contaminated Sediments

Abulencia, C.B., D.L. Wyborski, J. Garcia, M. Podar, W. Chen, S.H. Chang, H.W. Chang, D. Watson, E.I. Brodie, T.C. Hazen, and M. Keller.

Applied and Environmental Microbiology, Vol 72 No 5, p 3291-3301, 2006

The authors discuss the use of multiple displacement amplification (MDA) to amplify whole genomes sampled from sediments contaminated with nitrate and heavy metals. Biodiversity analysis and development of a library of microbes found in contaminated soils was made possible by amplifying the genomic DNA (gDNA). The MDA method was validated by analyzing amplified genome coverage from about five *Escherichia coli* cells, resulting in 99.2% genome coverage. Samples with extremely low cell densities were acquired from a contaminated site for DNA extraction, and clone libraries were constructed from the amplified gDNA. The libraries can be readily screened for native genes or any target of interest. Whole-genome amplification of metagenomic DNA from very minute microbial sources, while introducing an amplification bias, will allow access to genomic information not previously available. This work will help researchers discover and characterize microbes important to energy, biogeochemical cycles, and bioremediation.

[http://vimss.lbl.gov/publicfiles/29\\_Diversa\\_Poster.pdf](http://vimss.lbl.gov/publicfiles/29_Diversa_Poster.pdf)

## Estimation of Soil Superficial Conductivity in a Zone of Mature Oil Contamination Using DC Resistivity

Shevnin, V., O. Delgado Rodriguez, A. Mousatov, and A. Ryjov.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

The real cause of petrophysical anomalies is an increase of superficial conductivity greater than electrolytic conductivity change in pore spaces of contaminated soil, as has been demonstrated with the spectral IP method. The authors propose that DC resistivity also can provide information about superficial conductivity, which is the main cause of resistivity and petrophysical anomalies at contaminated sites. Superficial conductivity for soil is estimated on clay content (calculated on soil resistivity), groundwater salinity, and clay conductivity. Clay conductivity depends on porewater salinity and the cation exchange capacity of clay. Anomalous

clay content reflects an increase of internal surface area, whereas anomalous cation exchange capacity reflects an increase of surface charges at the mineral grain/electrolyte interface. Practical examples of superficial conductivity estimation at oil-contaminated sites are discussed with reference to resistivity and petrophysical anomalies.

Evaluating An Innovative Oxygen Sensor for Remote Subsurface Oxygen Measurements  
Millings, M.R., B.D. Riha, and W.K. Hyde, Savannah River National Lab., Aiken, SC.  
Report No: WSRC-STI-2006-00247, 48 pp, Oct 2006

Oxygen is a primary indicator of whether anaerobic reductive dechlorination and similar redox based processes contribute to natural attenuation remedies at sites contaminated with chlorinated solvent; thus, oxygen is a viable indicator parameter for documenting that a system is maintaining an anaerobic condition. A team of researchers investigated the adaptation of an optical sensor originally developed for oceanographic applications. Because of its design and operating principle, this optical sensor has potential for extended deployment and sensitivity at the low oxygen levels relevant to natural attenuation processes in the subsurface environment. The results of the research indicate that the optical tool will be useful for in situ long-term monitoring applications, although the traditional characterization tools continue to be appropriate for characterization activities.

<http://www.osti.gov/bridge/purl.cover.jsp?purl=/895044-71cAJx/>

Evaluating Helicopter Electromagnetic Data for Watershed Head Waters over an Abandoned Mine Complex

Giacinto, Joseph, Paul Petzrick, Leonard Rafalko  
SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Frequency domain helicopter electromagnetic surveys were conducted during 1999 over an area of 64 square kilometers that encompasses the area of the abandoned Coketon/Kempton Mine Complex in Maryland. Analysis of the electromagnetic data enabled investigators to identify areas of relatively high conductivity along the areas of historical surface mining activity (i.e., mine spoil piles). These conductive signatures are indicative of acid mine discharge production. Plumes of relatively high conductivity originating beneath unreclaimed mine spoil piles extend thousands of meters downgradient toward the flooded mine tunnels and known surface water seeps.

[http://www.ermist.us/ERMIST\\_PDFs/SAGEEP\\_2006\\_Conf.pdf](http://www.ermist.us/ERMIST_PDFs/SAGEEP_2006_Conf.pdf)

Evaluating the Bioavailability of Explosive Metabolites (MNX and TNX) in Soils Using Passive Sampling Devices

Zhang, B., P. N. Smith, and T. A. Anderson.

Journal of Chromatography A, Vol 1101 No 1-2, p 38-45, 2006

Researchers examined the uptake kinetics of two major RDX metabolites, MNX and TNX, into passive sampling devices (PSDs) and evaluated the ability of the PSDs to serve as surrogates for evaluating bioavailability of MNX and TNX. In studies in laboratory sand and two

soil types, TNX was more readily absorbed by PSDs than MNX. Soil conditions, especially organic matter content, affected MNX and TNX uptake into PSDs. Organic matter content also affected the ratio of MNX or TNX uptake into earthworms versus uptake into PSDs. A relatively good correlation between MNX and TNX uptake into PSDs and uptake into earthworms was obtained, indicating a linear relationship between PSD uptake and earthworm uptake. The study results demonstrate that C-18 PSDs can be used as a surrogate for soil organisms such as earthworms, providing a simple and easy chemical test for assessing the bioavailability of contaminants in soils.

#### Evaluation of the Structure/Cross-Reactivity Relationship of Polycyclic Aromatic Compounds Using an Enzyme-Linked Immunosorbent Assay Kit

Nording, Malin and Peter Haglund.

Analytica Chimica Acta, Vol 487 No 1, p 43-50, 2003

A commercially available enzyme-linked immunosorbent assay (ELISA) kit for detecting polycyclic aromatic hydrocarbons (PAHs) in soil was evaluated with regard to cross-reactivity using phenanthrene in methanol as reference substance. Representative PAHs (anthracene, naphthalene, and fluorene) and several polycyclic aromatic compounds (methyl-, phenyl-, and carbonyl-PAHs), typical of compounds found at former industrial sites, were chosen for elucidation of structure/cross-reactivity relationships. The authors emphasize the importance of a priori knowledge of sample composition for accurate interpretation of test results.

#### Evidence for Microbial Enhanced Electrical Conductivity in Hydrocarbon-Contaminated Sediments

Atekwana, E.A., E.A. Atekwana, D.D. Werkema, J.P. Allen, L.A. Smart, J.W. Duris, D.P. Cassidy, W.A. Sauck, and S. Rossbach.

Geophysical Research Letters, Vol 31 No 23, 2004

Laboratory column experiments to investigate the bulk electrical conductivity of sediments during microbial mineralization of diesel indicated that population numbers of oil-degrading microorganisms increased with a clear pattern of depth zonation within the contaminated column but not in the uncontaminated column. Ribosomal DNA intergenic spacer analysis showed a highly specialized microbial community in the contaminated column. The contaminated column exhibited temporal increases in bulk conductivity, dissolved inorganic carbon, and calcium, which suggests that the high bulk conductivity is due to enhanced mineral weathering from microbial activity. The greatest change in bulk conductivity occurred in sediments above the water table saturated with diesel. The study results indicate the potential utility of geophysical methodologies for investigating and monitoring microbial activity.

<http://www.epa.gov/esd//cmb/pdf/2004geophysreslett.pdf>

#### First-Order Kinetic Gas Generation Model Parameters for Wet Landfills

Reinhart, D.R., A.A. Faour, and H. You, Univ. of Central Florida, Orlando.

EPA 600-R-05-072, 66 pp, June 2005

Waste stabilization can be enhanced and accelerated so as to occur significantly more rapidly if a landfill is designed and operated as a bioreactor, primarily involving moisture addition. Enhanced waste stabilization will result in increased gas production; hence, the rate

constant and methane generation potential values will be different from those of conventional landfills. A literature review of wet-cell landfill gas generation and modeling was conducted to investigate and estimate first-order gas generation model parameters. Using case studies of gas collection from wet landfills, parameters were determined through statistical comparison of predicted and actual gas collection. Wet cells were observed to produce more gas at a faster rate than conventional landfills, particularly after closure and when more effective leachate recirculation was practiced.

<http://www.epa.gov/ord/NRMRL/pubs/600r05072/600r05072.pdf>

#### Field Testing of a Soil Corer Air Permeameter (SCAP) in Desert Soils

Chief, K. and T.P.A. Ferre (Univ. of Arizona, Tucson); B. Nijssen (3TIER Environmental Forecast Group, Inc., Seattle, WA).

Vadose Zone Journal, Vol 5 No 4, p 1257-1263, Nov 2006

Air permeability is an easy-to-measure soil parameter that is of direct importance in gas transport studies, as well as an indicator of soil hydraulic conductivity. A portable air permeameter has been developed that is compatible with a soil corer and ideal for desert soils. This paper presents a determination of the accuracy and applicable shape factors of the field instrument and a correlation of air permeability and hydraulic conductivity measurements.

#### Forensic Fingerprinting of Biomarkers for Oil Spill Characterization and Source Identification

Wang, Z., S.A. Stout, and M. Fingas.

Environmental Forensics, Vol 7 No 2, p 105-146, June 2006

The authors briefly review biomarker chemistry, biomarker characterization and quantification, biomarker distributions, weathering effects on biomarker composition, bicyclic biomarker sesquiterpanes and diamondoids, diagnostic ratios and cross-plots of biomarkers, unique biomarkers, application of biomarker fingerprinting techniques for spill source identification, and application of multivariate statistical analysis for biomarker fingerprinting.

#### Fort Ord Groundwater Remediation Studies, 2002-2005

Flegal, A.R. and P. Mantey (Univ. of California, Santa Cruz); C. Oldenburg (Lawrence Berkeley National Lab); P. Daley (Lawrence Livermore National Lab).

Report No: ERDC/CERL CR-06-2, 150 pp, Aug 2006

This report presents the results of collaborative studies of ground-water contamination, remediation, and monitoring at the former Fort Ord Army Base in northern Monterey County, CA. Three ground-water flow sensing systems were deployed in the spring of 2004 at the source area of a TCE plume at Operable Unit 1. The three systems employ entirely different modes of operation, but all three produce estimates of ground-water flow rate, and two produce estimates of the direction of ground-water flow. The Hydrotechnics(r) ISPFs system is a permanently installed device that utilizes high-precision temperature sensing over the surface of a heated cylindrical probe to measure heat displaced by ground-water flow. Inversion algorithms produce estimates of both horizontal and vertical flow vectors, as well as an azimuth for groundwater flow direction. The device is buried directly in the formation without casing or sandpack, and appears to produce data that agree well with standard analysis of aquifer conductivity generated



by pumping tests, combined with gradient analysis. It is designed to provide long-term logging of flow parameters with essentially no operator intervention or maintenance. The other two tools examined are designed to scan vertically through the water standing in the borehole and to log data that can be used to calculate flow rates, and in one case, flow direction. The RAS HPL system utilizes displacement of groundwater from the well by introduced low electrical conductivity water. As horizontal flow of formation water pushes this low-conductivity "tracer" from the well, continuous vertical recordings of conductivity recovery are made from which influx rates are calculated. The equipment is highly portable, and one well was logged with this system each day. The third tool, the LLNL scanning colloidal borescope, is also a portable logging tool that can be operated readily by a single worker, logging at a rate roughly equal to that of the RAS HPL system. Its operating principle is the video recording of back-lit particles by a down-hole CCD camera, illuminated from below by a high intensity lamp. Computer software digitizes the video recordings, detects and identifies particles between adjacent image "frames" and calculates horizontal displacement and direction. Many particles are monitored for each data record, which can then be reduced for plotting or statistical analysis. This collaborative project resulted in assessments of ground-water flow monitoring technologies; analyses of aquifer response, ground-water flow, and TCE plume evolution; simulation of in situ permeable flow sensors for measuring ground-water velocity; and remote sampling and analyses of inorganic contaminants in ground water. Four separate reports were developed from this project, and the results are combined in this integrated summary report.

[http://owwww.cecer.army.mil/techreports/Lampo\\_ord\\_groundwater/Lampo\\_ord\\_groundwater.pdf](http://owwww.cecer.army.mil/techreports/Lampo_ord_groundwater/Lampo_ord_groundwater.pdf)

#### Frequency Dependent Attenuation Analysis of Ground-Penetrating Radar Data

Bradford, John.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

In many subsurface materials, attenuation is approximately linear with frequency over the bandwidth of the GPR signal, with a slope characterized by a constant  $Q^*$  parameter. The author discusses the relationship of  $Q^*$  to the parameters describing Cole-Cole relaxation, noting that when the dominant GPR frequency is well above or well below the primary relaxation frequency,  $Q^*$  is a simple function of the ratio of real to imaginary parts of the dielectric permittivity. Near the relaxation frequency, a more complex relationship is required to describe the slope of the attenuation curve. Despite the complications, frequency-dependent attenuation analysis of reflection data can provide valuable subsurface information. Two field examples are provided to show that frequency-dependent attenuation analysis can locate anomalies associated with nonaqueous phase liquid contaminants.

### Geophysical and Hydrologic Studies of Shallow Aquifer Contamination, East Poplar Oil Field Area, Northeastern Montana

Smith, B.D., J.N. Thamke, and C. Tyrrel.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Areas of high conductivity in shallow aquifers in the East Poplar oil field area are being delineated by the U.S. Geological Survey in cooperation with several Tribes to interpret areas of saline water contamination. Following earlier surveys, an airborne electromagnetic survey was conducted during August 2004 in a 106 square-mile area that includes the East Poplar oil field. Airborne, ground, and borehole conductivity data were used to delineate subsurface areas of high conductivity and correlated with hydrologic data to indicate areas of contamination. USGS determined that handling and disposal of brine produced with oil in the East Poplar oil field area has resulted in contamination of not only the shallow aquifers, but also the Poplar River. In the years since the 1993 delineation, the quality of water from wells completed in the shallow aquifers in the East Poplar oil field changed markedly. The geophysical and hydrologic study is being used in ground water resource planning studies for the area. More information on this project at <http://mt.water.usgs.gov/cgi-bin/projects?B3Z01>

### Geophysical Characterization of an AMD-Generating Waste Rock Pile Using Ground and Borehole Techniques

Chouteau, M., O. Anterrieu, M. Aubertin, C. Dubreuil-Boisclair, and J. Poisson.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

At the Laronde copper-gold mine (Agnico-Eagle Ltd, Quebec), a geophysical characterization of a waste rock pile was started in 2002 to image the internal structure controlling the generation of acid mine drainage (AMD). Several field surveys were carried out in a test zone (30 m x 30 m) on top of the pile from 2002 to 2004 using GPR, an EM conductivity meter, and 2D resistivity. Infiltration tests and geophysical monitoring were repeated to map preferential flow paths. A four-layer model for the first 5 to 6 m was proposed, based mainly on electrical conductivities. Longer electric profiles with deeper penetration measured along and across the pile displayed contrasting resistivity distributions with large lateral variations, which was unexpected because previous small-scale resistivity surveys had shown layering.

### Geophysical Investigations of an Industrial Waste Landfill Contaminated by LNAPL and DNAPL at Ransart, Belgium

Deceuster, John and Olivier Kaufmann.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

At Ransart in Belgium, geophysical field experiments were conducted over an industrial waste landfill showing evidence of a LNAPL and DNAPL contamination. Buildings have been

dismantled, but foundations and buried storage tanks are still present. The site geology consists of a layer of backfill materials, partly clayed, and 2 to 3 meters thick. The bedrock is composed of carboniferous shales weathered on the first 2 to 4 meters. Trials of 3-D resistivity and IP tomographies and FDEM (EM31) methods were conducted to delineate LNAPL- and DNAPL-contaminated soils and water on a part of the site, with consistent results obtained from the two methods. Points of high conductivities were located and interpreted as the geoelectrical signature of hydrocarbon-contaminated soils. High gradients in the resistivity model were also identified that may be linked to the presence of contaminants at the top of the weathered bedrock.

#### Geophysical Monitoring Probes and Their Applications to Some Hydrogeologic Problems

Smart, Laura and William Sauck.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Geophysical probes were constructed to measure temperature and resistivity at the groundwater/stream interface and installed near a pond at intervals of 1 m, 3 m, 6 m, and 9 m perpendicular to the bank. Data are collected through a CR1000 Campbell Scientific datalogger connected to four relay multiplexers at 4-hr intervals under normal conditions and continuously during and for 2 hours following infiltration events. The results of this project are expected to support the capillary fringe effect and illustrate resistivity hysteresis in a field setting. Presently, one-time sediment sampling (at the time of borehole installation) is followed by quarterly or annual sampling for groundwater or soil gas. A system of geophysical probes would be able to monitor subsurface conditions with sampling intervals of minutes or hours on a continuous basis.

#### Geophysics Applied to Contaminant Studies: Papers Presented at SAGEEP from 1988 to 2006

Werkema, Douglas D. (ed.)

Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

This special CD contains papers that focus on investigation of contaminants in the subsurface. The selected papers have been compiled from 18 years of the proceedings of the annual Symposium for the Application of Geophysics to Environmental and Engineering Problems (SAGEEP), hosted by the Environmental and Engineering Geophysical Society ([www.eegs.org](http://www.eegs.org)).

#### GPR Monitoring of a DNAPL Release in a Natural Groundwater Flow Field

Hwang, Y.K., A. Endres, S. Piggott, and B. Parker.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

The authors present the results of years of study of the progress of a 1999 release of ~50 liters of a dense nonaqueous phase liquid (DNAPL) into a natural groundwater flow field at Canadian Forces Base Borden. Before and after the release until 2004, ground-penetration radar

(GPR) profiling with 200 MHz antennas was conducted to detect pools of the immiscible solvent and monitor their evolution with time. The presence and evolution of the contaminant pools was inferred from changes in reflectivity and was determined from signal amplitude and complex trace attribute variations between the background and post-release profiles. The results of these two techniques differ in some details, but overall they provided mutually consistent information about the state of the pools. Early data clearly show the development of two laterally extensive pools at different depths. These pools gradually decreased in size and reflectivity and disappeared almost completely by the end of the GPR monitoring period.

Helicopter Electromagnetic and Magnetic Survey Maps and Data, East Poplar Oil Field Area, August 2004, Fort Peck Indian Reservation, Northeastern Montana  
Smith, Bruce D., Joanna N. Thamke, Michael J. Cain, Christa Tyrrell, and Patricia L. Hill  
U.S. Geological Survey Open-File Report 2006-1216

This report is a data release for a helicopter electromagnetic and magnetic survey conducted during August 2004 in a 275-square-kilometer area that includes the East Poplar oil field on the Fort Peck Indian Reservation. The electromagnetic equipment consisted of six different coil-pair orientations that measured resistivity at separate frequencies, from 400 hertz to 140,000 hertz. The electromagnetic resistivity data were converted to six electrical conductivity grids, each representing different approximate depths of investigation. The range of subsurface investigation is comparable to the depth of shallow aquifers. Areas of high conductivity in shallow aquifers in the East Poplar oil field area are being delineated by the U.S. Geological Survey, in cooperation with the Fort Peck Assiniboine and Sioux Tribes, to map areas of saline-water plumes. Ground electromagnetic methods were first used during the early 1990s to delineate more than 31 square kilometers of high conductivity saline-water plumes in a portion of the East Poplar oil field area. In the 10 years since the first delineation, the quality of water from some wells completed in the shallow aquifers in the East Poplar oil field changed markedly. The extent of saline-water plumes in 2004 likely differs from that delineated in the early 1990s. The geophysical and hydrologic information from U.S. Geological Survey studies is being used by resource managers to develop ground-water resource plans for the area.

<http://pubs.usgs.gov/of/2006/1216/>

Hydrogeologic & Environmental Site Characterization of Shallow Bedrock at the Poudre River Site Assessment - Ft. Collins, Colorado

McGill, Robert, Preston Sowell, and James Fink

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

After a release of nonaqueous-phase liquid (NAPL) was observed in the Cache de Poudre River at Ft. Collins, CO, contractors conducted a survey to define depth to bedrock and bedrock topography. Free product (coal tar) associated with historical gas manufacturing at a plant in operation during the early 1900s was observed along the river bottom. A former landfill also occupied a portion of the site where the NAPL release was observed within the river. U.S. EPA needed to identify the sources (and responsible parties) conclusively. Because alluvium lies

approximately 10 to 40 feet thick within the site and the Pierre Shale forms the hydrologic bedrock for the area, shallow geophysical methods were applied. High-resolution resistivity (HRR) and ground penetrating radar (GPR) surveys were completed for non-invasive site characterization. The high clay content of near-surface soils inhibited signal penetration using GPR, but the HRR sections enhanced the comprehension of bedrock topography and identified pathways for coal tar migration to the river.

#### A High-Resolution Pore Water Sampler for Sandy Sediments

Berg, Peter and Karen J. McGlathery.

Limnology and Oceanography, Vol 46 No 1, p 203-210, 2001

A new technique is presented for collecting porewater samples in coarse- to fine-grained sandy sediments. The method can be used for both in situ sampling and for porewater extraction from sediment cores in the lab, with depth resolution as fine as 1 cm. The key device is a long, thin (~2 mm) stainless steel tube with a specially designed tip that functions as a filter. Porewater samples are collected by inserting the tube into the sediment at the desired depth and applying a light suction from a syringe connected to the tube. The sample is injected immediately into a vial through a syringe filter and stored for later analysis. This method gives porewater samples with a much higher depth resolution than can be obtained with lysimeters or sippers. The new technique also gives measurements that truly represent the time of collection. Sediment disturbance is minimal because of the small dimension of the tube. Sample extraction is less laborious than other techniques, requiring only one site visit and typically less than 1 minute of sampling time per sample. Guidelines are provided for choosing the appropriate sampling depth intervals as a function of the sample size.

#### A Hybrid Thermal Video and FTIR Spectrometer for Rapidly Locating and Characterizing Gas Leaks

Williams, D.J., D. Stone, C. Salvaggio, and D.A. Messinger.

Remote Sensing of Aerosol and Chemical Gases: Model Simulation, Assimilation, and Applications to Air Quality. Proceeding of SPIE--The International Society for Optical Engineering, Vol 6299, 4 pp, 2006

Undiscovered gas leaks in chemical plants and refinery operations can impact regional air quality and present a loss of product for industry. An efficient, accurate, and cost-effective method for detecting and quantifying fugitive emissions would both save industries money by identifying production losses and improve regional air quality. Though specialized thermal video systems have proven effective in rapidly locating gas leaks, these systems do not have the spectral resolution for compound identification. Passive FTIR spectrometers can be used for gas compound identification, but using these systems for facility surveys is problematic due to their small field of view. A hybrid approach has been developed that utilizes the thermal video system to locate gas plumes using real-time visualization of the leaks, coupled with the high spectral resolution FTIR spectrometer for compound identification and quantification. The prototype hybrid video/spectrometer system uses a sterling cooled thermal camera, operating in the MWIR (3-5 microns) with an additional notch filter set at around 3.4 microns, which allows for the visualization of gas compounds that absorb in this narrow spectral range, such as alkane hydrocarbons. This camera is positioned alongside a portable, high-speed, passive FTIR

spectrometer that has a spectral range of 2 to 25 microns and operates at 4 cm<sup>-1</sup> resolution. This system uses a 10 cm telescope foreoptic with an onboard blackbody for calibration. The two units are optically aligned using a turning mirror on the spectrometer's telescope with the video camera's output.

<http://www.cis.rit.edu/~cnspci/publications/629900-1.pdf>

#### Hyperspectral Sensing of Acid Mine Drainage: Two Colorado Case Studies

Hauff, P. (Spectral International, Inc., Arvada, CO); D. Peters (Peters Geosciences, Golden, CO); D. Coulter (Overhill Imaging and Cartography, Golden, CO); M. Sares and D. Bird (Colorado Geological Survey, Denver); F. Henderson (HENDCO Services, Nathrop, CO); E. Prosh (Spectral International, Inc., Arvada, CO). 2006 SME Annual Meeting and Exhibit & 7th ICARD, March 26-29, 2006, St. Louis, Missouri. American Society of Mining and Reclamation (ASMR), Lexington, KY. p 738-763, 2006

Hyperspectral high-resolution remote sensing technology is being used to characterize and map the source mineralogy of acid rock drainage (ARD), changes in downstream water quality, and the fluvial deposition of mine tailings downstream. Two case studies are presented. (1) The Lake Creek watershed is affected by natural ARD that emanates from two sources: subeconomic, sulfide-mineralized porphyry systems in the headwaters of two tributaries. Extreme metal and acid loading from source areas affects the watershed for 30 km downstream. (2) The main channel of the Arkansas River downstream of the Leadville District contains tailings distributed by fluvial processes. The tailings are a continuing source of metals loading to the river.

#### Identifying Compounds Despite Chromatographic Limitations: Organophosphates in Treated Sewage

Grange, A.H., L.I. Osemwengie, and G.W. Sovocool.  
LC-GC, Vol 21, p 1062-1076, 2003

The authors discuss the development of a high-resolution mass spectrometric technique to identify compounds in complex environmental extracts (e.g., sewage treatment plant effluents) based on GC/MS data alone. The latest version of the National Institute of Standards and Technology's mass spectral library, which is usually included within mass spectrometer data systems for automated comparison of analyte and library mass spectra, provides entries for 163,198 different compounds, while the Palisade library contains 495,000 compounds; however, the spectra of many compounds of interest are absent from mass spectral libraries. To assess the risk posed by treatment plant effluents flowing into water supplies, analytical tools are needed to identify compounds not suited to tentative identifications based on mass spectral library searches. Ion-composition elucidation (ICE), a high-resolution mass-spectrometric technique developed by U.S. EPA may fill this need. ICE provides the number of atoms of each element that comprise the ions observed in mass spectra. ICE is composed of two parts: mass peak profiling from selected ion recording data for data acquisition, and a profile generation model for automated data interpretation. When organophosphate compounds found in a treatment plant effluent presented a range of difficulty for compound identification from very distinctive mass spectra with unique library matches to those for which only the molecular ion was discernable

above the chemical noise, ICE provided confirmatory evidence for each compound and was essential for identifying two sets of isomeric compounds.

<http://www.epa.gov/nerlesd1/chemistry/ice/lcgc2.htm>

Identifying Metals Contamination in Groundwater Using Geochemical Correlation Evaluation  
Thorbjornsen, Karen and Jonathan Myers.

Environmental Forensics, Vol 8 No 1-2, p 25-35, Jan/June 2007

The authors present a methodology for distinguishing naturally occurring metals from contamination. The methodology is based on well-established geochemical processes, including trace element adsorption on suspended particulates and reductive dissolution. Four example cases are proved to illustrate application of the methodology.

Identifying the Source of Mystery Waterborne Oil Spills: A Case for Quantitative Chemical Fingerprinting

Stout, S.A., G.S. Douglas, A.D. Uhler, K.J. McCarthy, and S.D. Emsbo-Mattingly.

Journal Environmental Claims Journal, Vol 17 No 1, p 71-88, Winter 2005

Chemical fingerprinting methods both qualitative and quantitative can play an important role in the identification of waterborne oil spills originating from sources unknown. The qualitative approach relies upon ASTM methods that involve visual comparison of various chromatographic fingerprints obtained by GC/FID and GC/MS analysis of spill and candidate source oils. The quantitative approach, represented by the revised Nordtest methodology, relies upon concentration measurements of dozens of diagnostic chemicals, typically PAHs and biomarkers, and a subsequent statistical or numerical analysis of various diagnostic parameters calculated from these concentrations. The objectively interpreted quantitative approach is preferable for most oil spill investigations, rather than the subjective ASTM methods, particularly when the mystery spill and source oils are qualitatively similar, and the quantitative approach is required with spills that include mixed sources or pre-spill oil signatures.

Improvements in Environmental Microarray Specificity and Sensitivity

Biological and Environmental Research, Oak Ridge National Laboratory Annual Report, FY2006. p 17, Dec 2006

Gene probes on microarrays have to be able to distinguish between thousands of closely related genes that are often in low abundance in environmental samples. Most microarray probe design algorithms were created for use in single organism studies and use only one criterion to ensure specificity, such as the percentage of similarity; however, recent studies show that probe behavior and specificity may be predicted more reliably by examining multiple probe characteristics. By simultaneously considering the percentage of similarity, the longest identical stretch, and free energy of the hybridization, the individual criteria can be relaxed while more accurately ensuring the specificity of the probes. The level of specificity achieved using these criteria should provide at least species-level resolution in most cases and is critical for using microarrays in systems with mixed microbial species, as is typical in natural environments. Scientists have developed new probe design algorithms and a new program and applied them to design a functional gene array containing more than 24,000 probes for genes involved in

important microbially driven processes relevant to bioremediation and to carbon cycling and sequestration. Currently, microarrays require large amounts of nucleic acids--DNA or RNA--to ensure detection. To increase the sensitivity and applicability of microarrays to environmental samples where microbial species may be in low abundance, the researchers have also developed and optimized two separate techniques that allow unbiased amplification of nucleic acids from whole microbial communities. Through these amplification techniques it is now possible to analyze such communities with over 1,000 times less starting material, allowing access to microbial communities and species that previously were not available for study using these techniques.

#### An Indoor Test Campaign of the Tomography Long Path Differential Optical Absorption Spectroscopy Technique

Mettendorf, K.U., A. Hartl, and I. Pundt.

Journal of Environmental Monitoring, Vol 8 No 2, p 279-287, Feb 2006

A 2-D, long-path DOAS tomography measurement technique was validated in an indoor area of 10 m x 15 m with known concentration distributions of NO<sub>2</sub>. The setup was realized with three of the multibeam instruments recently developed by Pundt and Mettendorf, which allow simultaneous measurement along at least four light paths each. The configuration consisted of twelve simultaneous light beams, 39 horizontal light paths in total, and 18 different cylinder positions inside the field. Using the specified measurement setup, it was possible to measure and reconstruct one or two NO<sub>2</sub> plumes of 600 m diameter and average concentrations above 4.2 ppbv each, on a scale of 13.5 sq km. Theoretically, it should be possible to localize and quantify SO<sub>2</sub>, H<sub>2</sub>CO, HONO, and ozone plumes of 600 m diameter. Larger plumes can be measured with higher precision.

#### An Inexpensive, Submersible, Automatic Water Sampler

Martin, Jonathan B., Ray G. Thomas, and Kevin M Hartl.

Limnology and Oceanography, Vol 2, p 398-405, 2004

The automatic submersible water sampler described in this paper is small, lightweight, actuated by a microprocessor, and inexpensively and easily constructed. The device is suitable for use in karst aquifers, lakes, large rivers, and estuaries. The sampler consists of a pressure case, sample containers constructed of 10 spring-loaded 60 mL syringes connected to solenoid valves, and electronics to control opening and closing of the solenoid valves. Vacuum in the syringes keeps the springs compressed while the solenoid valves are closed. When a valve opens, the spring expands and draws water past a screen and/or filter into the syringe. Once the syringe is filled, the solenoid valve closes, storing the sample. More than one syringe can be opened simultaneously if more than 60 mL are required. Preservatives can be added to the syringe prior to deployment.

<http://aslo.org/lomethods/free/2004/0398.pdf>



### Influence of Relative Humidity and Ozone on the Sampling of Volatile Organic Compounds on Carbotrap/Carbosieve Adsorbents

Palluau, F., P. Mirabel, and M. Millet, UMR 7517 CNRS-Univ. Louis Pasteur, Strasbourg, France.

Environmental Monitoring and Assessment, Vol 127 No 1-3, p 177-187, Apr 2007

Atmospheric measurement of 11 selected VOCs--ethylene, acetylene, propene, 1-butene, 1,3-butadiene, 1-pentene, 1-hexene, benzene, toluene, ethylbenzene, m+p-xylene--by preconcentration by thermal desorption, analysis by gas chromatography, and identification and quantification with a flame ionization detector was developed and validated in term of metrology. The influence of climatic conditions (temperature and relative humidity) and the influence of chemical factors like ozone on sampling was of particular interest. Techniques for sampling the VOCs with adsorbent cartridges (Air Toxics) used with a UMEG sampler equipped in the inlet with a nafion(r) membrane were evaluated. The addition of a nafion® membrane in the inlet of the sampling system was required at various humidities; without this membrane, losses of compounds were observed for RH >50%. With this membrane, no loss of compounds at the end of 2 weeks of refrigerated storage was observed. No significant decrease of VOC concentration was observed after 14 days storage with ozone concentrations of 55 ppb among the compounds known to react with ozone, possibly because the nafion® membrane, when placed in the inlet of the sampler, can neutralize ozone before it enters the sampling tubes.

### Innovations in Site Characterization Case Study: The Role of a Conceptual Site Model for Expedited Site Characterization Using the Triad Approach at the Poudre River Site, Fort Collins, Colorado

EPA 542-R-06-007, 144 pp, Nov 2006

This case study examines how systematic planning, an evolving conceptual site model, dynamic work strategies, and real-time measurement technologies can be used to unravel complex contaminant distribution patterns and design a remedy at the Cache La Poudre River site. The investigation and design of the remedy involved a former burn landfill, hydrocarbon fuel contamination, and mobile manufactured gas plant (MGP) coal tar waste. The investigation has so far included the following mix of innovative and traditional technologies: electromagnetic induction and resistivity surveys, direct-push grab groundwater sampling and real-time analyses for volatile organic compounds (VOCs), passive soil gas survey to identify chlorinated solvents, passive diffusion bag sampling of groundwater exiting to surface water, auger drilling and trenching accompanied by fixed lab analyses, and open-path Fourier transform infrared (FTIR) spectroscopy to identify VOC emissions from the landfill area in three dimensions.

[http://www.clu-in.org/download/char/poudre\\_river\\_case\\_study.pdf](http://www.clu-in.org/download/char/poudre_river_case_study.pdf)

### Insights in Hydrodynamic and Geochemical Processes in a Valley-Fill ARD Waste-Rock Repository from an Autonomous, Multi Sensor Monitoring System

Wangerud, K. (U.S. EPA, Denver, CO); R. Versteeg and G. Heath (Idaho National Lab); R. Markiewicz, (U.S. Bureau of Reclamation, Denver).

2006 SME Annual Meeting and Exhibit & 7th ICARD, March 26-29, 2006, St. Louis, Missouri American Society of Mining and Reclamation (ASMR), Lexington, KY. p 2262-2280, 2006

At the Gilt Edge mine NPL site, a monitoring system was installed below a multi-layered geomembrane/rock/soil cover over a 65-acre sulfide-rock dump. This system incorporates hydrological, chemical, and physical sensors, as well as a 523-electrode resistivity system to track hydrodynamics. Continuously collected data are automatically stored in a web-accessible

database. A website front end and automated analysis routines provide on-demand and autonomous data analysis and near real-time information on repository processes.

An Integrated Geophysical Approach to Aid Remediation Efforts at the Exell Helium Plant in Masterson, TX

Burton, Bethany and Jared Abraham.

SAGEEP 2006: Symposium on the Application of Geophysics to Environmental and Engineering Problems, 2-6 April 2006, Bellevue, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, CD-ROM, 2006

The Exell Helium Plant near Masterson, TX, was constructed in the 1940s to produce high-grade helium for the country and was closed in the late 1990s. Geophysical surveys were conducted at the plant in preparation for transfer of ownership from the Bureau of Land Management for site disposal. A broadband EM induction system, dc resistivity, induced polarization, and subsequent integration with advancing GPS technologies were used in the investigation to derive estimates of potential contamination volumes and lateral extents to aid in remediation. Site-specific tasks included (1) delineation and volume estimation of potential contamination in two evaporation ponds, two oxidation ponds, a production blowdown pit and flare, and a former oil/water separator pit, (2) characterization of several historical spill areas, (3) characterization and volume calculation of a historical landfill, (4) location and characterization of pipelines and a chromium sludge pit for potential leaks and contamination, and (5) a site-wide reconnaissance survey for the location of undocumented burial pits. The investigators located no additional waste within the 300-acre property and found that hydrocarbons discharged to the evaporation ponds, oxidation ponds, and the blowdown pit had largely biodegraded, with little migration through the geologic section.

Integrated Microelectrodes for Electrochemical Analyses, Including Arsenic in Groundwater  
Deininger, D.J. and C.J. Kostelecky, Synkera Technologies Inc., Longmont, CO.

209th Electrochemical Society Meeting, Abstract #1254, Denver, CO, 7-12 May 2006

The authors have developed a process to fabricate a 3-electrode device as a single ceramic chip for arsenic determination. Gold microband and platinum counter electrodes were prepared in a rugged ceramic body using an inexpensive and efficient manufacturing process. A silver/silver chloride reference electrode was screen printed on top of the electrode chip using commercially available materials. The platinum and gold electrodes can be fabricated in a variety of lengths and geometries to tailor the performance of the electrode chips. The electrochemical behavior of the embedded platinum and gold electrodes has been tested using square wave voltammetry and potassium ferricyanide to detect As(III) in water.

Integrated Resistivity Imaging and GPR Studies to Assess Groundwater Pollution near Landfill Site, Nagpur-India

Pujari, Paras and Madan Nanoti.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Tools like the multi-electrode resistivity imaging system have enabled investigators to map contaminant plumes generated from landfill sites. At a landfill site in Nagpur, India, dipole-dipole and Wenner configurations were used in resistivity imaging. The dipole-dipole configuration was successful in providing better horizontal resolution of inhomogeneities. The findings from resistivity imaging were corroborated by analytical results from groundwater samples collected close to the profile. Higher contamination of samples downgradient of the site was indicated as compared to samples upgradient. Samples located downgradient and in the immediate vicinity exhibited significant conductivity values.

Inventory of Radiological Methodologies for Sites Contaminated with Radioactive Materials

U.S. EPA, Office of Air and Radiation, Montgomery, AL.

EPA 402-R-06-007, 116 pp, Oct 2006

This document is part of a continuing effort by the Office of Radiation and Indoor Air and the Office of Superfund Remediation and Technology Innovation to provide guidance to EPA site managers and their contractors responsible for managing the cleanup of sites contaminated with radioactive materials. The document is an overview of radioanalytical methodologies that can be used for the identification and quantification of radionuclides likely to be found in soil and water at cleanup sites contaminated with radioactive materials. It is not a catalog of analytical methods, but rather is intended to assist project managers in understanding the concepts, requirements, practices, and limitations of radioanalytical laboratory analyses of environmental samples. It describes appropriate radioanalytical methodologies used to characterize environmental samples containing radionuclides, including screening methodologies and radionuclide-specific analyses and includes a primer on radiation physics and the basics of radiochemistry.

<http://www.clu-in.org/download/char/402-r-06-007.pdf>

Investigating the Geoelectrical Response of Hydrocarbon Contamination Undergoing Biodegradation

Werkema, D.D., Jr. (U.S. EPA, Las Vegas, NV); E.A. Atekwana (Univ. of Missouri-Rolla); A.L. Endres (Univ. of Waterloo); W.A. Sauck (Western Michigan Univ.); D.P. Cassidy (Univ. Laval). Geophysical Research Letters, Vol 30 No 12, p 49-1--49-4, 2003

A proposed geoelectrical model for hydrocarbon contaminated sites predicts high conductivities coincident with the contaminated zone, attributing the high conductivities to mineral weathering resulting from byproducts of microbial redox processes. To evaluate the conductive model, in situ vertical conductivity measurements were acquired from a site contaminated with light nonaqueous phase liquid (LNAPL). High conductivities were observed coincident with the zone of contamination and within the smear zone influenced by seasonal

water table fluctuations. The authors infer this zone to be an active zone of biodegradation and suggest significant microbial degradation under partially saturated conditions. A simple Archie's Law analysis shows large porewater conductivities necessary to reproduce the bulk conductivity measured at the contaminated location.

[http://www.epa.gov/esd//cmb/pdf/Werkema\\_et\\_al\\_2003.pdf](http://www.epa.gov/esd//cmb/pdf/Werkema_et_al_2003.pdf)

Investigation of Indoor Air Quality in Structures Located above VOC-Contaminated Groundwater, Year Two, Part 1: Evaluation of Soil Vapor Intrusion at Mount Holly Site, New Jersey

Golder Associates, Inc., Cherry Hill, NJ.

New Jersey Department of Environmental Protection (NJDEP), Trenton, NJ. 234 pp, July 2006

This project was conducted to evaluate soil vapor intrusion into buildings through field measurements, to compare different existing guidance for vapor intrusion, and to perform site-specific mathematical modeling of vapor intrusion. The subsurface contamination at the Mount Holly site consists of petroleum hydrocarbons (gasoline) released at a former industrial site. Contamination has migrated off site below a residential area with single-family dwellings. The field investigation scope in the off-site residential area consisted of a hydrogeological and groundwater contamination assessment; the testing of soil vapor, slab vapor, and indoor air; and evaluation and monitoring of building conditions relevant to soil vapor intrusion. This study highlights the importance of detailed assessment of conditions and processes near the water table when higher levels of contamination are located below the water table, including the appropriate use of monitoring-well vapor-phase data. A decline in the water table as a result of prolonged drought or pumping would increase the potential for elevated soil vapor concentrations above the water table, though whether this would translate to a significant potential for soil vapor intrusion into homes is uncertain.

<http://www.state.nj.us/dep/dsr/air/yr2-part1-vapor-intrusion.pdf>

Investigation of Indoor Air Quality in Structures Located above VOC-Contaminated Groundwater, Year Two, Part 2: Evaluation of Soil Vapor Intrusion at Wall Township Site, New Jersey

Golder Associates, Inc., Cherry Hill, NJ.

New Jersey Department of Environmental Protection (NJDEP), Trenton, NJ. 100 pp, July 2006

The focus of this study is evaluation of soil vapor intrusion into houses located downgradient from the White Swan dry cleaner site. Through analysis of groundwater, soil vapor, and indoor air data, valuable information on soil vapor attenuation factors was obtained. The buildings in the study area consist of small- to medium-sized residential dwellings with basements. A comprehensive evaluation of monitoring data for the Wall Township site indicates a positive relationship between groundwater and indoor air PCE concentrations. This trend, together with a spatial evaluation that indicates a pattern of elevated indoor PCE concentrations in houses above the highest groundwater concentration areas, provides evidence for soil vapor intrusion. In addition, the measured indoor air PCE concentrations in a number of houses were significantly above typical background levels for PCE published in the literature. There is significant variability in the alpha factors for individual homes. The data analysis for

groundwater alphas suggested that the alphas were significantly higher for houses with sumps, compared to houses without.

<http://www.state.nj.us/dep/dsr/air/yr2-part2-vapor-%20intrusion.pdf>

#### Laboratory-Scale Investigation of the Effect of Microbial Growth on the Geoelectrical Properties of Porous Media

Davis, Caroline, Estella Atekwana, Philip Bottrell, Joseph Heidenreich, Eliot Atekwana, Lee Slater, Silvia Rossbach

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

A column experiment was conducted to investigate the effect of microbial growth on low-frequency electrical properties of porous media. Additionally, the researchers sought to determine the relative magnitude of the effect of microbial growth on low-frequency electrical properties (electrolytic and interfacial conduction). In columns packed with quartz sand, the active columns were amended with nutrients, diesel, and bacteria, and the control columns with only nutrients and diesel. Changes in the electrical properties of the sediment were monitored via induced polarization measurements, and changes in the fluid chemistry related to microbial growth and activity were assessed by monitoring the geochemical parameters of fluid conductivity, pH, optical density, and total organic carbon. Microbial growth increased significantly between day 15 and day 30 before declining during the 45-day experiment. The interfacial electrical parameters (phase and imaginary conductivity) in the biotic column increased steadily to peak values on day 25 before decreasing, while the control column showed a slight decrease in interfacial conduction over time. The magnitude of the changes in the interfacial conduction of the biotic column was more than 10 times greater than that of the control column. The close correspondence of the peaks in the interfacial conduction parameters and microbial growth suggest that the IP response was due to microbial induced changes in the petrophysical properties of the porous media rather than to changes in the electrolytic conductivity.

#### Laser-Based Instrumentation for Real-Time, In-Situ Measurements of Combustible Gases, Combustion By-Products, & Suppression Concentrations

McNesby, Kevin L., Andrzej W. Miziolek, and D. R. Reed Skaggs, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD.

Strategic Environmental Research and Development Program, 34 pp, Sep 2002

This final report summarizes results of a multi-year project to implement laser-based instrumentation for real-time, in situ measurements of combustible gases, combustion byproducts, and suppression concentrations during suppression of flames and explosions on board Army combat vehicles. The first two years of the project involved transitioning proven, laboratory-based methods (TDLAS employing phase-sensitive detection and laser-induced breakdown spectroscopy, or LIBS) from the lab at the ARL to the crew compartment fire test facility at the Aberdeen Test Center. The study results suggest that gas sensing using near-infrared lasers will probably continue gaining market share, although it seems likely that a

transition will occur in which a single laser detecting a single gas is replaced either by an addressable source or by a single, broadly tunable laser. Near-infrared devices for gas sensing will likely continue to be used because of the ease of transmission through optical fibers, room temperature operation, high signal to noise ratio through phase-sensitive detection techniques, and because of the large tel-com infrastructure that continues development of electronics that may easily be adapted to gas sensing; however, room-temperature operation mid-infrared lasers (quantum cascade and interband cascade designs) offer all of the advantages of phase-sensitive detection available with near-infrared DFBs, with the huge advantage of gas sensing using the fundamental vibrational transition. It seems likely that future microphotonic sensors will employ suites of arrays of near- and mid-infrared devices, and that these devices will gradually displace conventional Michelson interferometer-based systems in the lab and in the field.

[http://www.bfrl.nist.gov/866/NGP/publications/3A1\\_McNesby\\_Final\\_Technical\\_Report\\_15\\_Sept.pdf](http://www.bfrl.nist.gov/866/NGP/publications/3A1_McNesby_Final_Technical_Report_15_Sept.pdf)

List of Leak Detection Evaluations for UST Systems, 14th Edition

National Work Group on Leak Detection Evaluations (NWGLDE), 435 pp, Jan 2007

This list of leak detection evaluations was prepared by a work group consisting of state and EPA members. The list is limited to evaluations of leak detection equipment and procedures or systems conducted by an "independent third-party evaluator" and then reviewed by the work group. The NWGLDE does not evaluate the methods or equipment, and appearance on this list does NOT mean they are "approved" or automatically acceptable for use in any particular state or local jurisdiction. Each data sheet reports parameters and data values for methods, equipment, and software that are specific to the most current third-party evaluation submitted to the NWGLDE. Subsequent modifications or changes to the method, equipment, or software may produce parameters and data values that are significantly different than the listed third-party evaluation parameters and data values. It is the responsibility of the local implementing agency to accept or reject those modifications or changes. Updates to this list are posted on the NWGLDE website ([www.nwglde.org](http://www.nwglde.org)) under "News and Events."

<http://www.nwglde.org/downloads.html>

List of Potential Information Requirements in Metal Leaching/Acid Rock Drainage Assessment and Mitigation Work

Price, William A.

Natural Resources Canada, Mine Environment Neutral Drainage (MEND) Program, MEND Report 5.10E, 24 pp, Jan 2005

This guide was first put together to list information requirements for authors preparing mining-site case studies. Because the depth and breadth of knowledge required for the assessment of mining sites can be overwhelming, it is possible to overlook critical pieces of information. When developing or reviewing mining plans, this guide can be used to identify outstanding information requirements, factors to consider, information or factors that are not applicable, and where data collection or planning is under way or completed.

<http://www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mend/reports/report510-e.pdf>

## LNAPL Behavior in Fractured Rock: Implications for Characterization and Remediation

Hardisty, P.E., J. Roher, and J. Dottridge.

2004 U.S. EPA/NGWA Fractured Rock Conference: State of the Science and Measuring Success in Remediation, Portland, Maine, 13-15 September 2004

Characterization of light nonaqueous phase liquids (LNAPLs)-contaminated fractured rock masses should focus on determination of fracture network and rock matrix properties, understanding of groundwater surface fluctuation dynamics, and consideration of spatial LNAPL distribution. A combination of techniques--many not used in porous medium investigations--can be used to develop a detailed conceptual model, e.g., coring, angled holes, digital borehole imaging, and fracture casting for aperture determination. The data obtained with these methods can provide information on LNAPL occurrence and behavior, allow LNAPL spill volume to be estimated, indicate future movement, and ultimately support more effective and economic remedial decision making.

[http://clu-in.org/products/siteprof/2004fracrockconf/cdr\\_pdfs/indexed/group1/129.pdf](http://clu-in.org/products/siteprof/2004fracrockconf/cdr_pdfs/indexed/group1/129.pdf)

## Long-Distance Remote Laser-Induced Breakdown Spectroscopy Using Filamentation in Air

Stelmaszczyk, K. and P. Rohwetter (Freie Univ. Berlin); G. Mejean, J. Yu, E. Salmon, J. Kasparian, R. Ackermann, and J.-P. Wolf (Univ. Claude Bernard Lyon); L. Woeste (Freie Univ. Berlin).

Applied Physics Letters, Vol 85 No 18, p 3977-3979, 1 Nov 2004

A laser-induced breakdown spectroscopy (LIBS) scheme based on filamentation induced by the nonlinear propagation of unfocused ultrashort laser pulses can achieve remote elemental analysis at distances up to 90 meters. A detailed signal analysis suggests that this remote filament-induced breakdown spectroscopy technique can be extended up to the kilometer range. LIBS is particularly suitable for remote analysis of hazardous materials.

[http://pelasim47.univ-lyon1.fr/publications/letter\\_libs.pdf](http://pelasim47.univ-lyon1.fr/publications/letter_libs.pdf)

## Low-Level Detection of Ethanol and 1,4-Dioxane Using the Eclipse Purge-and-Trap Sample Concentrator

Fulton, Tracy M. and Laura Chambers, OI Analytical.

LCGC: The Application Notebook, p 31, June 2006

According to the authors, both ethanol and 1,4-dioxane can be detected at 10 ppb with no degradation of peak shape by optimizing the trap type, sample temperature, and temperature of the trap during purge on the Eclipse Sample Concentrator.

<http://www.lcgcmag.com/lcgc/data/articlestandard/lcgc/242006/335537/article.pdf>

## Luminotox: a Tool for Rapid Toxicity Testing

Environment Canada, 4 pp, Mar 2005

LuminoTox is a new, easy-to-use tool for toxicity assessment that has been tested on various types of wastewaters to validate its effectiveness and scope of use. LuminoTox has been proven effective for rapid toxicity detection (15 minutes) in both treated and untreated effluents, including municipal wastewaters, leachates from landfill sites, pulp and paper mill effluents, and mining industry effluents. It was also found to be effective for assessing the level of toxicity reduction in effluents following passage through a treatment system, such as an aerated pond or

sequential biological reactor. LuminoTox is a tool that can complement routine physico-chemical analyses and standardized bioassays by rapidly providing an index of the toxic potential of effluents.

[http://www.qc.ec.gc.ca/dpe/Anglais/dpe\\_main\\_en.asp?innov\\_fiche\\_200503a](http://www.qc.ec.gc.ca/dpe/Anglais/dpe_main_en.asp?innov_fiche_200503a)

Magnetic Susceptibility Measurements as Proxy Method to Monitor Soil Pollution: Development of Experimental Protocols for Field Surveys

D'Emilio, M. (CNISM--Istituto di Metodologie per l'Analisi Ambientale--CNR, Tito, Italy); D. Chianese; R. Coppola; M. Macchiato; M. Ragosta.

Environmental Monitoring and Assessment, Vol 125 Nos 1-3, p 137-146, Feb 2007

A two-part procedure is presented for collecting magnetic susceptibility measurements to interpret them as proxy variables for monitoring heavy metals in soils. In the first part of the procedure, laboratory tests were conducted to evaluate for two different probes the effective investigation depth for soil, the measurement reproducibility under different conditions, and the influence of water content. The in situ measurements obtained from the two probes were then compared. The second part of the procedure comprised tests to evaluate the relationships between heavy metal levels and magnetic susceptibility values of soil samples. The variability of the magnetic susceptibility measurements was examined in soil samples spiked with known concentrations of heavy metals, followed by a study of the correlation between magnetic susceptibility values and metal concentrations in field samples. A careful check of the experimental procedure is crucial for using magnetic susceptibility measurements to monitor heavy metals in situ.

Man Portable LIBS (MP-LIBS): A Backpack Based Laboratory LIBS System for Measurements from Contact to 5 Meters

Walters, R.A. and J.B. Rose, Ocean Optics, Inc.

Pittcon 2006, Abstract 1890-2.

Ocean Optics supported by ARL has developed a Man-Portable LIBS system for use in real-time measurement of possible hazardous substances. Its survey wand or probe includes a miniature 75 mJ active Q-switched laser and sampling optics. The backpack encompasses a pulse-gated, high-resolution broadband spectrometer, the LIBS3000gh, a Pentium M-class computer, and a lithium polymer battery. Features include an LCD or heads-up display (HUD), a control joystick on the survey wand, wireless communications, a software "library" for analyte identification, a GPS tag, and Argon displacement at the sample point. A lens-based projection probe replaces the wand for analysis at up to 5 meters. Production versions will be hermetically sealed for easy decontamination using chlorine bleach and a water rinse. The MP-LIBS is designed to enable first responders to identify unknown substances instantaneously.

Mass Balance: a Key to Advancing Monitored and Enhanced Attenuation for Chlorinated Solvents

Looney, B., K. Vangelas, K.-M. Adams, F.H. Chappelle, T.O. Early, and C.H. Sink.

Report No: WSRC-STI-2006-00082, 91 pp, June 2006

Monitored natural attenuation (MNA) and enhanced attenuation (EA) are two environmental management strategies that rely on a variety of attenuation processes to degrade or immobilize contaminants and are implemented at appropriate sites by demonstrating that contaminant plumes have low risk and are stable or shrinking. The concept of a mass balance



between the loading and attenuation of contaminants in a ground-water system is a powerful framework for conceptualizing and documenting the relative stability of a contaminant plume. As a result, this concept has significant potential to support appropriate implementation of MNA and EA. For mass balance to be useful in engineering practice, however, it is necessary to quantify it in practical ways that facilitate overall site remediation and which are consistent with existing regulatory guidance. Two divergent philosophies--empirical and deterministic--exist for quantifying plume stability, and the approaches are described in this report. Case studies over the past decade demonstrate that empirical and deterministic approaches to MNA/EA are not mutually exclusive. The studies document that improved decision support and efficiency result by combining these methods based on the individual challenges presented by a given site. Whenever possible, the empirical approach is used to quantify mass loading and attenuation capacity (mass of contaminant/unit time) at particular sites to demonstrate effectively the efficiency of ongoing natural attenuation processes in accordance with current regulatory guidance. The monitoring well networks needed to apply the empirical approach can also yield estimates of the hydrologic, geochemical, and biological parameters needed to apply deterministic models. The deterministic models can then be used to estimate how contaminant behavior will change over time as contaminant mass is removed or if attenuation mechanisms are enhanced by engineering methods. The dual use of these empirical and deterministic approaches can help integrate the use of MNA and EA for overall site remediation.

[http://www.osti.gov/bridge/product.biblio.jsp?query\\_id=0&page=0&osti\\_id=891672](http://www.osti.gov/bridge/product.biblio.jsp?query_id=0&page=0&osti_id=891672)

#### Measurement of Fugitive Emissions at a Landfill Practicing Leachate Recirculation and Air Injection

Modrak, M., R.A. Hashmonay, R. Varma, and R. Kagann, ARCADIS G&M, Inc., Durham, NC. EPA 600-R-05-088, 51 pp, Aug 2005

EPA conducted a fugitive emission characterization study at the Three Rivers Solid Waste Technology Center Landfill located near Jackson, SC. The survey area is a two-acre research and development site that practices leachate recirculation and air injection. The site is located within the Subtitle D Landfill. The study was conducted to evaluate emissions of fugitive gases, such as methane and hazardous air pollutants, at the site using scanning open-path Fourier transform infrared spectrometers and open-path tunable diode laser absorption spectroscopy. The study involved a technique that uses ground-based optical remote sensing technology, known as radial plume mapping. The horizontal radial plume mapping method was used to map surface methane concentrations, and the vertical radial plume mapping method was used to measure emission fluxes downwind of the site.

<http://www.epa.gov/ord/NRMRL/pubs/600r05088/600r05088.pdf>

#### Measurement of Moisture Conditions within Hazardous Waste Storage Facilities Using the Deep Diviner Moisture Probe

Dobchuk, B. (O'Kane Consultants Inc., Saskatoon, SK, Canada); J. Dobchuk (Convergent Motion Control, Inc., Saskatoon, SK); M. O'Kane, (O'Kane Consultants Inc., Calgary, AB); S. Barbour (Univ. of Saskatchewan, Saskatoon, SK). 2006 SME Annual Meeting and Exhibit & 7th ICARD, March 26-29, 2006, St. Louis, Missouri. American Society of Mining and Reclamation (ASMR), Lexington, KY. p 528-538, 2006

The Deep Diviner is a deep, continuous-profile moisture-monitoring system. A winch/cable assembly was developed to lower the sensor within a PVC access tube to take automated measurements of moisture content at user-specified depth intervals and to record these

on a portable data logger. The authors describe the development of the Deep Diviner and present data from laboratory and full-scale evaluations of the prototype.

#### Measurements of Dissolved Methylmercury in Natural Waters Using Diffusive Gradients in Thin Film (DGT)

Clarisse, Olivier and Holger Hintelmann.

Journal of Environmental Monitoring, Vol 8 No 12, p 1242-1247, Dec 2006

A diffusive gradient in thin films (DGT) technique for measuring methylmercury (MeHg) concentrations in natural waters was developed using 3-mercaptopropyl-functionalized silica gel to preconcentrate the methylmercury. MeHg is efficiently accumulated at a pH range of 3 to 9. Concentrations determined by DGT deployed for different time periods in the field were not different statistically from results obtained through direct measurements. The overall detection limit of the method is 1 pg of MeHg, corresponding to ~30 pg/L MeHg in a water sample from a typical DGT device deployed for 24 hours. Lower MeHg concentrations can be obtained using longer deployment times or thinner diffusive gel layers. Features and limitations of environmental applications of this new technique are discussed.

#### Measuring Trace Gases in Plumes from Hyperspectral Remotely Sensed Data

Marion, R., R. Michel, C. Faye.

IEEE Transactions on Geoscience and Remote Sensing, Vol 42 No 4, p 854-864, 2004

A method designated "joint reflectance and gas estimator" (JRGE) was developed to estimate a set of atmospheric gas concentrations in an unknown surface reflectance context from hyperspectral images. It is applicable for clear atmospheres without any aerosol in a spectral range between approximately 800 and 2,500 nm. JRGE smoothes and interpolates the reflectance for gas estimation but also provides nonsmoothed reflectance spectra. The method preserved various mineral absorption features in the AVIRIS image of the Cuprite Mining District test site.

#### Mercury Measurements for Solids Made Rapidly, Simply, and Inexpensively

Hinners, T.A.

Seminar for U.S. EPA Region 9 ORD Product Expo, 8 February 2005

While traditional methods for determining mercury in solid samples involve the use of aggressive chemicals to dissolve the matrix and the use of other chemicals to properly reduce the mercury to the volatile elemental form, pyrolysis-based analyzers can be used by directly weighing the solid in a sampling boat and initiating the instrumental analysis for total mercury.

[http://clu.informstudio/r9productexpo\\_020805/ppframe2.cfm?s=121&p=3&res=800x600&simul=1](http://clu.informstudio/r9productexpo_020805/ppframe2.cfm?s=121&p=3&res=800x600&simul=1)

#### A Metal Detector Study to Locate Inactive Small Arms Range Impact Areas

Takasaki, K.C. (U.S. Army Corps of Engineers, Seattle District, WA); W.A. Martin and V.F. Medina (U.S. Army Environmental Lab, Vicksburg, MS); J.R. Marsh (U.S. Army Corps of Engineers, Seattle District).

Soil and Sediment Contamination, Vol 15 No 4, p 379-386, July/Aug 2006

In a search of a 20-acre site for several former .45-caliber Thompson sub-machine gun ranges near the Fort Lewis Evergreen Range, a study was conducted of the efficacy of using a hand-held metal detector to locate the bullet impact areas. A two-man team performed the study

using the Garrett Graphic Target Imaging(tm) (GTI) 2500 and confirmed bullet detection by excavation. The Garrett GTI 2500 has an LCD screen that provides information on the potential size and depth of the object causing the signal. Three impact areas were successfully identified and marked using a global positioning system. This detection strategy saved substantial sampling time, decreased the sampling area by 93%, and saved over \$35,000.

#### Method 9013A: Cyanide Extraction Procedure for Solids and Oils

U.S. EPA, SW-846, 10 pp, Nov 2004

Method 9013A is a procedure for extracting soluble and insoluble cyanides from solids and oil wastes prior to analysis using aqueous-based determinative methods. The resulting extraction solutions may be distilled and analyzed for total cyanide and/or cyanides amenable to chlorination (Methods 9010, 9012 and 9014) as well as analyzed for metal cyanide complexes (Method 9015). The method is applicable to oil, solid, and multiphasic sample matrices.

<http://www.epa.gov/epaoswer/hazwaste/test/pdfs/9013a.pdf>

#### Method 9015: Metal Cyanide Complexes by Anion Exchange Chromatography and UV Detection

U.S. EPA, SW-846, 51 pp, Nov 2004

This test method uses anion exchange chromatography and UV detection for the quantitative measurement of the individual anionic metal cyanide complexes of iron, cobalt, silver, gold, copper, and nickel in waters and solid waste extracts. There is no derivatization and little if any sample preparation. The analytes are measured directly in aqueous solution as the anionic cyanide complex species. Solid waste samples may also be analyzed through the use of a simple alkaline extraction procedure (Method 9013). Metal cyanide concentrations in the ug/L range are determined using on-line sample preconcentration.

<http://www.epa.gov/epaoswer/hazwaste/test/pdfs/9015.pdf>

#### A Method for the Analysis of Tracer Tests in Groundwater

Carlier, E. and C. Boulema, Univ. d'Artois, Lens, France.

Quarterly Journal of Engineering Geology & Hydrogeology, Vol 35 No 3, p 291-294, Aug 2002

A method that enables determination of the turnover time, the coefficient of dispersion, and the dispersivity from dye tracer tests was first tested on a column of sand and subsequently on chalk. The chalk test led to method modification because the coefficient of dispersion depends on the location of the plume's center. The authors compare experimental and computed data and discuss the validity of the method.

#### Micro Analytical Systems Department Technology: Micropyrolyzer

Sandia National Laboratories Fact Sheet, 4 pp, 2003

A hand-held gas-phase chemical analysis system has been developed that uses three microfabricated stages. The first stage is a preconcentrator that collects and concentrates analytes. The second stage is a gas chromatographic (GC) column used to achieve analyte separation. The third stage is an array of surface acoustic wave (SAW) sensors used to detect the separated analytes. The chemical analysis system--uChemLab(tm)--combines these stages along

with a miniature pump. This combination approach provides rapid and discriminating analyses, and a pattern of detector responses, providing an additional stage of discrimination. This fact sheet describes advances toward a new application for the preconcentrator and additional applications for uChemLab(tm).

[http://www.ca.sandia.gov/chembio/tech\\_projects/detection/factsheets/famebrochure.pdf](http://www.ca.sandia.gov/chembio/tech_projects/detection/factsheets/famebrochure.pdf)

#### Microarray-Based Analysis of Microbial Community RNAs by Whole-Community RNA Amplification

Gao, H., Z.K. Yang, T.J. Gentry, L. Wu, C.W. Schadt, and J. Zhou.

Applied and Environmental Microbiology, Vol 73 No 2, p 563-571, Jan 2007

Whole-community RNA amplification (WCRA) has been developed to provide sufficient amounts of mRNAs from environmental samples for microarray analysis. This method employs fusion primers (6 to 9 random nucleotides with an attached T7 promoter) for the first-strand synthesis. About 1,200- to 1,800-fold amplification was obtained with amounts of the RNA templates ranging from 10 to 100 ng, and very representative detection was obtained with 50 to 100 ng total RNA. Evaluation with a *Shewanella oneidensis* fur strain revealed that the high-throughput amplification method developed by the authors could preserve the original abundance relationships of mRNAs. The method was applied to the active microbial populations in a denitrifying fluidized bed reactor used for denitrification of contaminated groundwater and ethanol-stimulated groundwater samples for uranium reduction. The genes expressed were consistent with the expected functions of the bioreactor and groundwater system, suggesting that this approach is useful for analyzing the functional activities of microbial communities.

<http://aem.asm.org/cgi/reprint/AEM.01771-06v1.pdf>

#### Microbially Catalyzed Calcite Precipitation in Porous Media: Potential for Geophysical Mapping of Precipitate Distribution

Fujita, Y. and G.D. Redden (Idaho National Lab); R.W. Smith (Univ. of Idaho-Idaho Falls); Y. Wu (Rutgers Univ., Newark, NJ); R.J. Versteeg (Idaho National Lab).

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS34A-05, 2006

The potential for stimulating microbially mediated urea hydrolysis to promote the precipitation of calcium carbonate and the co-precipitation of trace metals as a method for treating systems contaminated with Sr-90 is being studied. Urea hydrolysis results in an increase in both pH and carbonate alkalinity, and these factors can promote carbonate mineral precipitation. The ability to hydrolyze urea is widespread among subsurface microorganisms; hence, remediation schemes based upon this approach could rely on indigenous organisms. In environments that favor calcite stability, this approach could result in long-term contaminant stabilization. In developing this concept into a practical remediation approach, it is a particular challenge to understand how the system permeability and fluid flow changes over time as coupled to the precipitation rates and distribution of the precipitate. Study of these coupled processes involves testing the application of complex resistivity as a means of mapping the distribution of precipitated calcite in a porous media column.

## Microbiological Comparison of Two Field-Scale Sulfate-Reducing Permeable Reactive Zones Treating Mine Drainage

Hübel, Sage R., Luciana P. Pereyra, Amy Pruden, and Kenneth F. Reardon, Colorado State University, Fort Collins.

AGU Hydrology Days 2006, 20 - 22 March, Colorado State University: Program Abstracts.

Mine drainage is typically high in sulfates and heavy metals and low in pH. Biological treatment through the implementation of a sulfate-reducing permeable reactive zone (SR-PRZ) installed transverse to flow is an attractive treatment option because of the low cost and maintenance requirements. Two field-scale SR-PRZs were installed at the Luttrell and Peerless Jenny King mines, both located in the Ten Mile Creek area near Helena, MT. A suite of molecular biological tools was used to characterize the microbial communities of these two different field bioreactors with the goal of understanding the relationships between the microbial community, operating conditions, and performance. Compost-based substrate was used to promote the growth of a complex microbial community, including sulfate-reducing bacteria (SRB), in each bioreactor. The two bioreactors were sampled at multiple locations and depths in June 2005, and Peerless Jenny King was sampled again in August 2005. The overall bacterial composition of the microbial community was characterized through cloning of polymerase chain reaction (PCR)-amplified 16S rRNA genes followed by restriction digest screening and DNA sequencing. The SRB populations were directly examined using two approaches: cloning of the *apsA* gene and quantitative real-time PCR (Q-PCR). The *apsA* gene is specific to SRB and was PCR-amplified, cloned, and sequenced. This method revealed that two main SRB groups are prevalent in both bioreactors. The two SRB groups are both *Desulfovibrio* spp., and one is known to be particularly aerotolerant. The analysis also uncovered the presence of *Thiobacillus denitrificans*, a bacterium with the highly undesirable ability to oxidize sulfides in the presence of nitrate or oxygen. The second approach, Q-PCR, was used to quantify two specific groups of SRB, *Desulfovibrio* and *Desulfobacter*. The population sizes of these two SRB groups were found to vary with depth in both bioreactors. The results of this study demonstrate that the two different sulfate-reducing bioreactors harbor significantly different bacterial communities. The ultimate goal of this research is to develop an improved understanding of the microbiology of SR-PRZs to improve the reliability of design and operation.

## Microcantilever Technology for Chemical, Biological and Explosive Material Detection

Adams, J.D., B. Rogers, and R. Whitten, Nevada Nanotech Systems, Inc., Reno, NV.

208th Electrochemical Society Meeting, Los Angeles, CA, 16-21 October 2005. Abstract #1287

Nevada Nanotech Systems, Inc., is developing a microcantilever-based detection system that will measure trace concentrations of explosives, toxic chemicals, and biological agents in air. The baseline sensor unit includes sensor array, electronics, power supply, and air handling. The proposed device would measure about two cubic inches, run on a small watch battery, and cost a few hundred dollars. Using data gathered by a self-sensing array of microcantilevers, pattern recognition techniques such as principle component analysis are capable of discriminating among chemicals. Preliminary demonstrations of the microcantilever platform have been conducted. Its capacity is illustrated by discrimination of five chemicals, including four toxic industrial chemicals, at ppm and ppb concentrations.

### A Mini Drivepoint Sampler for Measuring Pore Water Solute Concentrations in the Hyporheic Zone of Sand-Bottom Streams

Duff, J.H., F. Murphy, C.C. Fuller, F.J. Triska, J.W. Harvey, and A.P. Jackman.

Limnology and Oceanography, Vol 43 No 6, p 1378-1383, 1998

A mini drivepoint solution sampling (MINIPOINT) technique was developed to collect porewater samples at 2.5-cm vertical resolution in gravel streambeds. The sampler consisted of six small-diameter stainless steel drivepoints arranged in a 10-cm-diameter circular array. In a simple procedure, the sampler was installed in the streambed to preset drivepoint depths of 2.5, 5.0, 7.5, 10.0, 12.5, and 15.0 cm. Sampler performance was evaluated by measuring the vertical gradient of chloride concentration in pore water beneath the streambed as established by uninterrupted injection to the stream for 3 d. Pore-water samples were withdrawn from all drivepoints simultaneously yielding detailed solute profiles in the hyporheic zone that could not have been determined without a method for close interval vertical sampling without disturbing natural logic mixing between stream water and groundwater.

[http://aslo.org/lo/toc/vol\\_43/issue\\_6/1378.pdf](http://aslo.org/lo/toc/vol_43/issue_6/1378.pdf)

### Modeling the Spectral Effects of Water and Soil as Surface Contaminants in a High Resolution Optical Image Simulation

Strackerjan, K., L. Smith, and J. Kerekes, Rochester Inst. of Technology, Rochester, NY.

Proceedings of the 2006 International Geoscience and Remote Sensing Symposium, 4 pp, 2006

Selected environmental effects have been introduced into the Digital Imaging and Remote Sensing Image Generation (DIRSIG) model. DIRSIG is capable of producing high-resolution images to the scale of meters using computer-aided design models of buildings, vehicles, trees, and other elements of the landscape across the full optical spectrum. The goal is to subject a given material to these environmental effects and then to model the modified reflected or emitted spectrum accurately. Initially work will model moisture and dust on surfaces by implementing a model of the effects of a thin layer of water and soil coverage, respectively, on the spectral reflectance and emittance of different materials. Using new techniques for field instruments in a laboratory setting, the relationship between the surface contaminant and its effect on the target has been established. These results will be incorporated into DIRSIG for wider use.

[http://www.cis.rit.edu/people/faculty/kerekes/pdfs/IGARSS\\_2006\\_Strackerjan\\_Modeling.pdf](http://www.cis.rit.edu/people/faculty/kerekes/pdfs/IGARSS_2006_Strackerjan_Modeling.pdf)

### Monitoring Hydrocarbon Biodegradation with DC Resistivity

Werkema, D.D., E. Atekwana, E. Atekwana, S. Rossbach, J. Duris, J. Allen, L. Smart, and W. Sauck.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

Research results suggest that geophysical measurements might be used to infer the rate of change of biodegradation and alteration of the subsurface hydrocarbon-impacted media.

## Monitoring of a Controlled DNAPL Spill Using a Prototype Dielectric Logging Tool

Brown, P., A. Mazzella, and D. Wright.

EPA 600-R-06-092 (NTIS: PB2007-101961), 2006

The U.S. Geological Survey utilized their prototype dielectric logging tool to monitor a controlled dense nonaqueous-phase liquid (DNAPL) spill into a large tank located at the University of California Richmond Field Station. The tank contained multiple layers of sand and clayey sand. To assist in the interpretation of the logging results, finite-difference time-domain numerical simulations were performed using a model that approximated the physical experiment. Modeling results agree well with the physical results and demonstrate qualitatively how the tool responded to the DNAPL spilled in the tank. Logging results show that the tool successfully monitored DNAPL movement throughout the duration of the experiment and was sensitive to changes in relative DNAPL saturation. Anomalous zones in the data correspond to areas where DNAPL was observed in images recorded by a color borehole video camera. Results suggest that a quantitative interpretation of the dielectric tool data is possible, given necessary system calibration data.

## Monitoring of Microbial Reduction and Reoxidation Activities in the FRC Sites Using a Comprehensive Functional Gene Array

He, Z., J.D. Van Nostrand, L. Wu, T.J. Gentry, Y. Deng, C.W. Schadt, W. Wu, J. Liebich, S.C. Chong, B. Gu, P. Jardine, C. Criddle, D. Watson, T.C. Hazen, and J. Zhou.

Joint Genomics: GTL Awardee Workshop V and Metabolic Engineering 2007, Bethesda, Maryland, 11-14 February 2007

GeoChip, a novel comprehensive functional gene microarray, contains 24,243 oligonucleotide (50mer) probes and covers > 10,000 genes in >150 functional groups involved in nitrogen, carbon, sulfur, and phosphorus cycling; metal reduction and resistance; and organic contaminant degradation. Due to the nature of functional gene sequences (highly homologous and incomplete), it is challenging to select specific oligonucleotides for some functional genes using routine probe design strategies. To tackle those problems, the authors used the following strategies: (1) retrieved sequences were aligned, and only the shared regions of the functional genes were used for probe design; (2) experimentally established oligonucleotide design criteria and a novel software tool, CommOligo (specifically developed to deal with highly similar sequences), were used for GeoChip; (3) gene- and group-specific probes were designed to detect both divergent and closely related sequences; and (4) multiple probes for each sequence or each group of sequences were designed to increase the confidence of detection. GeoChip is a powerful generic tool, and can be used to (1) survey any environmental samples (e.g., groundwater, soil, sediments, oil fields, deep sea, animal guts), (2) study biogeochemical processes and functional activities of microbial communities; (3) explore direct linkages of microbial genes/populations to ecosystem processes and functions; and (4) detect functional genes and/or organisms in a particular environment. Three related studies were conducted on the dynamics and stability of microbial genes and associated communities during bioremediation and reoxidation periods at the Oak Ridge Field Research Center (FRC) and Hanford site using the developed array. First, GeoChip was used to track the dynamics of metal-reducing bacteria and associated communities for an in situ bioremediation project at the FRC site in Oak Ridge. Second, the developed array was applied to study the processes of reoxidation (a period after microbial reduction) in microbial communities. Third, the developed GeoChip was used to evaluate functional

communities at a lactate-fed chromium reduction system at the Hanford site. Due to exponential increases in the numbers of genes and the number of sequences for each gene, the array will be updated continuously, if possible, to reflect the sequence information currently available in public databases and personal collections. The third generation array will cover almost three times more gene sequences and have more features. An extended abstract is available. [http://www.ornl.gov/gtl2007/abstracts/Arkin\\_21.pdf](http://www.ornl.gov/gtl2007/abstracts/Arkin_21.pdf)

#### Mystery Oil Spill: Solving an Environmental Puzzle Using Geophysical Techniques

Parish, Joseph and Robert Helverson.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

A geophysical investigation was conducted in November 2004 to locate the source of an oil spill that manifested intermittently in a stream at a suburban neighborhood near Philadelphia, PA. The deployment involved a Geonics EM61 Mark 2 Time Domain metal detector interfaced with a Trimble AG132 GPS system for good resolution, minimal effects from cultural noise, and positioning efficiency and accuracy. The EM61 survey successfully identified several candidate anomalies, including an anomaly near a residential home that was found to contain contaminated soil from investigation sampling. Subsequent exploratory excavation revealed the anomaly source to be a leaking underground storage tank, 3 by 6 feet in dimension and 2.5 feet below ground surface. The excavators also found that the tank was installed less than one foot above an unsealed terracotta drainage pipe. Laboratory analysis and fingerprinting confirmed the tank as the source of the spill.

#### Naval Base Ventura County, Port Hueneme, California--EPA Characterization Test Cell: Report on Electromagnetic Surveys in the Test Cell Area

Werkema, D.D., U.S. EPA, Las Vegas, NV.

EPA 600-S-04-073, 15 pp, 2004

The objective of the geophysical surveys at the EPA Characterization Test Cell (CTC) area at Naval Base Ventura County is to locate geophysical anomalies indicative of metallic objects within the area of the cell. The goal was to provide background metallic object content at the site for future construction and research activities. To achieve the objective, detailed reconnaissance geophysical mapping using electromagnetic induction (EMI) was conducted throughout the site using the Geonics EM-31 and the Geonics EM-61. A series of geophysical property maps were produced from the survey results: an EM-31 quadrature response (bulk ground conductivity), EM-31 in-phase response, EM-61 bottom channel, EM-61 top channel, and the EM-61 normalized differential channel. The EM-31 revealed bulk ground conductivities, while the EM-61 revealed responses due to ferrous and/or non-ferrous metallic objects. The EM-31 maps show no anomalous responses within the area surveyed. An increasing bulk ground conductivity gradient was observed along the eastern and southeastern portions of the site and interpreted as due to a nearby chainlink fence as well as to an underground utility along the southeastern boundary. The EM-61 maps reveal several discrete anomalies indicative of small metallic objects throughout the site and one large discrete anomaly of no known cause. In



addition, a few north/south trending linear anomalies may represent elongate pipe-like metallic objects or surface material contrasts. Overall, the EMI surveys suggest the locations of several subsurface metallic objects that might be encountered during excavation and construction. If present, these objects should be removed prior to construction of the CTC.

[http://www.epa.gov/esd/cmb/pdf/nbvc\\_usepa\\_ctc\\_em\\_survey\\_report.pdf](http://www.epa.gov/esd/cmb/pdf/nbvc_usepa_ctc_em_survey_report.pdf)

NEMC 2006: The 22nd Annual National Environmental Monitoring Conference, Arlington, Virginia, 28-31 August 2006

U.S. EPA, NELAC Institute, Independent Laboratory Institute, and American Council of Independent Laboratories.

The National Environmental Monitoring conference (NEMC) provides the principal forum for addressing policy and technical issues affecting monitoring in all environmental media (i.e., water, air, soil, and wastes) and across all environmental programs. The 2006 meeting hosted over a dozen sessions: special session on detection and quantitation limits; organic methods; inorganic methods; air; chemical speciation of arsenic; chemical speciation of Hg, Se, and Br species; chemical speciation of Cr(VI); managing uncertainty; information management; Homeland Security; Superfund analytical services; the performance approach; accreditation; and perchlorate. The following perchlorate presentations are available on line: (1) A Two-Dimensional Ion Chromatographic Method for the Ultra-Low Level Determination of Perchlorate and Bromate Using Suppressed Conductivity Detection; (2) Trace Level Determination of Perchlorate in Soils and Saltwater by Tandem Suppressed Conductivity and Mass Spectrometry (IC/MS); (3) The Highest Levels of Perchlorate Detected in Foods and Beverages by Ion Chromatography Coupled with Tandem Mass Spectrometry (IC-ESIMS/MS); and (4) Rapid Determination of Perchlorate Anion in Foods and Environmental Samples by Ion Chromatography-Tandem Mass Spectrometry.

<http://www.nemc.us/proceedings/2006proceedings.pdf>

A New Rechargeable Dialysis Pore Water Sampler for Monitoring Sub-Aqueous In-Situ Sediment Caps

Jacobs, P.H., Technical Univ. of Hamburg-Harburg, Germany.

Water Research, Vol 36 No 12, p 3121-3129, 2002

Modification of the basic peeper design to develop a new rechargeable dialysis porewater sampler has been adapted to the requirements of monitoring in situ sediment remediation techniques, such as capping. Sampler recharging and repeated sampling permits a temporal as well as a spatial resolution of porewater geochemistry. The author discusses construction details, materials used, and the reliability of the sampling and recharging process. The peeper is designed for 1-m depth profile with spatial resolution of 1/5.5cm. The practical temporal resolution, which depends chiefly on sediment characteristics, is 1/3 weeks. Sample volumes of 20 cubic cm were obtained from a depth of 8 m without mixing of sample and recharge water. The field test with an exposure time of 8 months showed no occurrence of clogging of either the membranes or the sample tubing. The study results indicate that this new type of sampler can be employed as a tool for monitoring contaminants at the sediment-to-water interface and within an in situ cap.

New Techniques for Quantitative Isolation of MeHg from Difficult Sediment Matrixes: Nitric Acid leaching and Solid Phase Extraction Coupled to Hg-Thiourea Ion Chromatography CVAFS  
Shade, C. (Quicksilver Scientific LLC); B. Vermillion (Univ. of Illinois, Urbana-Champaign); H. Hintelmann (Trent Univ.); R. Hudson (Univ. of Illinois).  
Eighth International Conference on Mercury as a Global Pollutant, Madison, Wisconsin, 6-11 August 2006

Although acid leaching techniques applied in concert with solvent extraction for the isolation of MeHg from the sediment matrix shows very low inherent transmethylation potential, there are two main issues: (1) H<sub>2</sub>SO<sub>4</sub> leaching with added KBr and CuSO<sub>4</sub> has shown variable analyte recovery, and (2) the organic solvents used in the extraction--methylene chloride and toluene--are highly toxic, and the associated phase-separations are tedious. For the first problem, research results indicate a distinct advantage to the use of HNO<sub>3</sub> and CuSO<sub>4</sub> as the extracting medium, due apparently to matrix alteration through the oxidizing nature of HNO<sub>3</sub>, with 4-6 M acid concentration being critical to complete recovery in highly organic wetland sediments. For the second issue, a new solid-phase extraction (SPE) approach has been developed to replace organic solvents altogether. The new non-toxic SPE technique showed identical isolation performance to solvent extraction and also increased throughput capacity and scalability of the method. The SPE resin is easily eluted with acidic thiourea and then analyzed by Hg-thiourea ion chromatography with CVAFS detection. The combination of HNO<sub>3</sub>/CuSO<sub>4</sub> leaching and SPE extraction produces excellent recoveries, high throughput, and negligible artifacts.

On the Semi-Quantification of Polycyclic Aromatic Hydrocarbons in Contaminated Soil by an Enzyme-Linked Immunosorbent Assay Kit

Nording, M., K. Frech, Y. Persson, M. Forsman, and P. Haglund.  
Analytica Chimica Acta, Vol 555 No 1, p 107-113, 2006

A commercially available enzyme-linked immunosorbent assay (ELISA) kit, the PAH RISC(r) soil test, can be used for efficient screening of soils contaminated with polycyclic aromatic hydrocarbons (PAHs), though performance may vary from site to site due to differences in soil properties and contamination profiles. Researchers investigated factors that might contribute to ELISA measurement uncertainties, such as contributions from co-extracted (non-target) compounds, extraction efficiency, and differences in cross-reactivity among the target analytes. The investigators observed that ELISA does not seem to respond to non-target compounds in soil extracts to any great extent, and PAHs of high molecular weight were extracted more efficiently with PLE than with methanol agitation, which is used for ELISA. Taking this factor and the cross-reactivity of the individual PAHs into consideration, the researchers concluded that the ELISA results were in good agreement with GC-MS results.

An Optimization of a Bioassay for Toluene Analogs using Bioluminescence Reporter Strain KG1206

Kong, In Chul, Yeungnam Univ., Gyungbuk, Korea.  
Soil and Sediment Contamination, Vol 15 No 3, p 231-239, May/June 2006

A genetically engineered strain of *P. putida* mt-2 KG1206 contains the intact TOL plasmid and a plasmid with the Pm-lux gene. In a study, bioluminescence was produced by direct (m-toluate and benzoate) and indirect inducers (toluene analogs). This bioluminescence-

producing strain was used for the quantification of m-toluate in soil, and a quantification protocol for pollutant was developed for standardization. Values determined by bioluminescence were in the range of 75 min at ~158 % maximum of their true concentration as determined by HPLC analysis. Statistical analysis indicates that this bioluminescence strain is useful for quantifying specific pollutant in environmental system, though more investigation is required for pollutant mixtures.

#### Overview of Physical Models and Statistical Approaches for Weak Gaseous Plume Detection Using Passive Infrared Hyperspectral Imagery

Burr, Tom and Nicolas Hengartner, Los Alamos National Lab, Los Alamos NM.

Sensors, Vol 6 No 12, p 1721-1750, Dec 2006

The performance of weak gaseous plume-detection methods in hyperspectral long-wave infrared imagery depends on scene-specific conditions, such as the ability to properly estimate atmospheric transmission, the accuracy of estimated chemical signatures, and background clutter. This paper reviews commonly-applied physical models in the context of weak plume identification and quantification, identifies inherent error sources (as well as those introduced by making simplifying assumptions), and indicates research areas.

<http://www.mdpi.org/sensors/papers/s6121721.pdf>

#### Oxidation as a Pre-Step in Determination of Organophosphorus Compounds by the AChE-TLS Bioassay

Kralj, M.B., P. Trebze, and M. Franko, Nova Gorica Polytechnic, Nova Gorica, Slovenia.

Acta Chimica Slovenica, Vol 53 No 1, p 43-51, 2006

Oxidation experiments with different commonly used oxidants and reducing agents has shown that the reliable, rapid, and selective oxidation of organophosphorus pesticides (i.e., malathion, diazinon, chlorpyrifos, and azinphos-methyl) to their respective oxons (malaoxon, diazoxon, chlorpyrifos-oxon, azinphos-methyl-oxon) can be achieved with N-bromosuccinimide and sodium hypochlorite within five minutes. The oxidizing and reducing agents were added directly to water or juice. With no need for a preconcentration, extraction, or other analytical step, time of analysis was reduced in contrast to previously reported oxidation procedures. The AChE bioassay based on the investigated oxidation procedure enables determination of thio-organophosphorus compounds in the ppb concentration range in less than 15 minutes.

<http://acta.chem-soc.si/53/53-1-43.pdf>

#### Passive Fluxmeters: Application as a Characterization/Monitoring Tool for Monitored Natural Attenuation of Chlorinated Solvents

Vangelas, K., B.B. Looney, K. Hatfield, M.D. Annable, J. Cho, and M.R. Millings.

Report No: WSRC-STI-2006-00315, 47 pp, Dec 2006

Contaminant mass flux is generally defined as the mass of contaminant passing through a unit area per unit time, while the integrated mass flux or contaminant mass discharge is the spatial integration of the contaminant flux over a control plane. This report presents results of a research project in which passive fluxmeters (PFMs) were used to measure changes of chlorinated ethene fluxes along the axis of a ground-water contaminant plume. A PFM is a

down-hole device that operates passively to provide direct, in situ, cumulative measures of both local water and dissolved contaminant fluxes. A transect of PFMs provides information that, when spatially integrated, generates estimates of contaminant mass discharge. Multiple PFM transects located downgradient from a source area can be used to estimate spatial changes in contaminant mass discharge, which are needed to calculate contaminant mass balances and characterize the intensity of natural attenuation.

[http://www.osti.gov/bridge/product.biblio.jsp?query\\_id=0&page=0&osti\\_id=896532](http://www.osti.gov/bridge/product.biblio.jsp?query_id=0&page=0&osti_id=896532)

Passive Samplers for Chromatographic Analyses of Gases in Groundwater Reveal High Concentrations of Hydrogen  
Biological and Environmental Research, Oak Ridge National Laboratory Annual Report, FY2006. p 5-6, Dec 2006

In the ORNL Environmental Sciences Division, Brian Spalding and David Watson have adapted a simple, in situ, passive, dissolved-gas groundwater sampler (a short length of silicone tubing attached to a syringe) for in situ collection of equilibrium gas samples. After spending several days immersed in groundwater, the device is retrieved, and the sample can be injected from the device directly into a gas chromatograph. The device enables a simpler field-collection and sample-handling process than the commonly used "bubble stripping" method for H<sub>2</sub> analyses. The researchers modified a gas chromatograph by sequencing a thermal conductivity detector followed by a reductive gas detector so that linear calibration of H<sub>2</sub> over the range 0.2 through 200,000 ppmv was attained for a 0.5-mL gas sample. Inclusion of the thermal conductivity detector allowed the simultaneous quantification of other fixed gases (O<sub>2</sub>, CO<sub>2</sub>, He, and Ne) to which the reductive gas detector was not responsive. Uptake kinetics for H<sub>2</sub> and He indicated that the passive sampler reached equilibrium within 12 h of immersion in water. Field testing of these passive samplers revealed unusually large equilibrium gas-phase H<sub>2</sub> concentrations in groundwater--ranging from 0.1 to 13.9% by volume--in 11 monitoring wells surrounding 4 former radiological wastewater disposal ponds at the Y-12 plant in Oak Ridge, TN. [See B.P. Spalding and D.B. Watson, "Measurement of dissolved H<sub>2</sub>, O<sub>2</sub>, and CO<sub>2</sub> in groundwater using passive samplers for gas chromatographic analyses," *Environmental Science and Technology* 40(24):7861-7867(2006)]

Pathways and Kinetics of MTBE Degradation

Church, Clinton Dean, Ph.D. dissertation, Oregon Health & Science University, 106 pp, Jan 2007

Studies were conducted (1) to provide a means for analyzing for MTBE and its degradation products and (2) to refine the understanding of MTBE fate in groundwater by providing a detailed assessment of the major pathways and kinetics of MTBE degradation under controlled laboratory conditions. The findings show that MTBE and its degradation byproducts are subject to both biotic and abiotic degradation and also measure the kinetics of the degradation observed. Column studies showed that MTBE is subject to microbial degradation, with a rate corresponding to a 2-to-3 year half-life in uncontaminated soils and in the presence of oxygen. Most of the MTBE that occurs in association with gasoline spills will not be degraded by this mechanism, however, because the plumes are typically anaerobic, and compounds more readily biodegraded are usually present. Studies with PM-1, an MTBE-degrading isolate, showed

that PM-1 is capable of mineralizing MTBE and that MTBE and other fuel oxygenates are degraded by similar pathways and at similar rates. Engineered treatment systems using PM-1 have since been shown to be an efficient means of treating water contaminated by MTBE. The tert-butyl formate (TBF) hydrolysis study shows that TBF is subject to neutral as well as acid- and base-catalyzed hydrolysis. The rates of this degradation at 22 degrees C correspond to half-lives of 5 days, 6 hours, and 11 minutes at pH values of 7, 2, and 11, respectively. It examines why, though TBF is the primary degradation product of many MTBE degradation pathways, it is rarely seen in field samples. Fenton reagent studies show that MTBE is subject to a previously undescribed environmental degradation mechanism. This mechanism involves delivery of the reactants (hydrogen peroxide and MTBE, in a raindrop) to a catalytic surface (iron oxyhydroxides in sediments). The subsequent degradation arises from the production of hydroxyl radical via a Fenton-like reaction, and the reaction of the hydroxyl radical thus formed with MTBE. Evidence shows that this mechanism may account for as much as 8% of atmospherically deposited MTBE under ideal conditions. All of these studies relied on the simultaneous analysis of MTBE disappearance and product appearance, analyses that could not be accomplished at environmentally relevant concentrations using conventional purge and trap techniques. Because of this analytical objective, the first task of the project was to design an analytical protocol to make the rest of the project possible. This protocol involves direct aqueous injection with detection by mass spectrometry (Chapter 2).

<http://drl.ohsu.edu/cgi-bin/showfile.exe?CISOROOT=/etd&CISOPTR=174>

#### Performance of Semipermeable Membrane Devices for Sampling of Organic Contaminants in Groundwater

Vrana, B., H. Paschke, A. Paschke, P. Popp, and G. Schuurmann.

Journal of Environmental Monitoring, Vol 7 No 5, p 500-508, May 2005

The field performance of semi-permeable membrane devices (SPMDs) for monitoring organic contaminants in groundwater was evaluated in an area contaminated by chemical wastes that included chlorinated hydrocarbons. Contaminant distribution was assessed using a combination of passive sampling with SPMDs and non-target, semi-quantitative GC-MS analysis. More than 100 contaminants were identified and determined semi-quantitatively in SPMD samples. The study indicated a very limited mobility of hydrophobic substances in dissolved form in the aquifer. The SPMD in situ extraction potential was limited by groundwater flow when the exchange volume of well water during an exposure was lower than the SPMD clearance volume for the analytes.

#### Performance Optimisation of a Passive Sampler for Monitoring Hydrophobic Organic Pollutants in Water

Vrana, B., G. Mills, R. Greenwood, J. Knutsson, K. Svensson, and G. Morrison.

Journal of Environmental Monitoring, Vol 7 No 6, p 612-620, June 2005

An integrative passive sampler comprising a C18 Empore disk sorbent receiving phase fitted with a low-density polyethylene membrane was optimized for the measurement of time-weighted average concentrations of hydrophobic micro-contaminants in water. A small volume of n-octanol--a solvent with high permeability for target analytes--was added to the interstitial space between the receiving sorbent phase and the polyethylene diffusion-limiting membrane.

Lowering the internal sampler resistance to mass transfer of hydrophobic organic chemicals via the addition of n-octanol achieved substantial improvement in the rate of sampling and sampling precision.

#### Post-Remediation Evaluation of a LNAPL Site Using Electrical Resistivity Imaging

Halihan, T., S. Paxton, I. Graham, T. Fenstemaker, and M. Riley.

Journal of Environmental Monitoring, Vol 7 No 4, p 283-287, Apr 2005

Electrical resistivity image data indicate that light nonaqueous-phase liquid (LNAPL) contaminants, such as gasoline, exist outside a delineated and remediated area in Golden, OK. Confirmed by drilling, the data also show that LNAPL exists between monitoring and remediation wells that show low contaminant levels. Even after two phases of remediation work, the electrical images provided the drilling location for the highest concentration of hydrocarbon yet found on the site.

#### The Potential of Field Spectroscopy for the Assessment of Sediment Properties in River Floodplains

Kooistra, L. (Univ. of Nijmegen, The Netherlands); J. Wanders and G.F. Epema (Wageningen Univ.); R.S.E.W. Leuven, R. Wehrens, and L.M.C. Buydens (Univ. of Nijmegen).

Analytica Chimica Acta, Vol 484, p 189-200, 2003

Researchers used partial least squares regression to establish a relationship between soil reflectance spectra measured using visible-near-infrared (VNIR) spectroscopy under field conditions and the organic matter and clay content of the soil. Spectra were acquired with a field spectrometer in a recently reconstructed river floodplain. Under varying surface conditions, field spectroscopy combined with multivariate calibration results in a qualitative relation for organic matter and clay content, though more accurate results are obtained under laboratory conditions. Soil moisture and vegetation cover had a negative influence on the prediction capabilities for both soil properties. While the in situ measurements are not as accurate as physical analysis, the data obtained are useful for rapid soil characterization and remote sensing applications.

<http://www.cac.science.ru.nl/research/publications/PDFs/kooistra2003.pdf>

#### Preconcentration/Preelution Ion Chromatography for the Determination of Perchlorate in Complex Samples

Tian, K., J.E. Canas, P.K. Dasgupta, and T.A. Anderson.

Talanta, Vol 65 No 3, p 750-755, 2005

Determination of perchlorate by ion chromatography (IC) with an online preconcentration and preelution technique was applied to different sample types containing large concentrations of matrix anions that would otherwise interfere with analysis via conventional IC. The approach removed most of the matrix anions effectively, exhibiting resistance to the interferences commonly encountered in a high ionic strength background. The investigators analyzed for low-level perchlorate in variety of matrices: synthetic high ionic strength solutions, tissue extracts, and hydroponic nitrate fertilizer samples. The described method provided equal to or better recovery of perchlorate than EPA Method 314.0. Method detection limits of perchlorate in hydroponic fertilizer samples with this method are the lowest reported to date.

## Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater

Interstate Technology & Regulatory Council (ITRC) Diffusion/Passive Sampler Team.  
DSP-5, 121 pp, Feb 2007

This guidance contains protocols for five passive sampling technologies. "Passive sampling" is synonymous with "no-purge sampling." The technologies included in this document include the Snap Sampler(tm) and Hydrasleeve(tm) (grab-type well water samplers); a regenerated-cellulose dialysis membrane sampler and a rigid, porous polyethylene sampler (diffusion/equilibrium-type samplers); and the GORE(tm) Module (a diffusion and sorption-type sampler). According to 16 states responding to a questionnaire, there are no specific regulatory barriers to using passive samplers to collect groundwater samples; however, guidance does exist that specifically requires purge-type sampling, thereby requiring an exception for passive samplers to be used. Most states require some sort of comparative study if passive samplers are intended to replace an existing sampling program. It is the consensus of the ITRC Diffusion/Passive Sampler Team that the samplers discussed in this protocol document have been validated through laboratory and field testing. When the samplers are deployed appropriately, the resulting data are reliable and accurate.

<http://www.itrcweb.org/Documents/DSP-5.pdf>

## Quantifying Minimum Monolith Size and Solute Dilution from Multi-Compartment Percolation Sampler Data

de Rooij, G.H. (Wageningen Univ., The Netherlands); O.A. Cirpka (Swiss Federal Inst. of Aquatic Science & Technology, Duebendorf, Switzerland); F. Stagnitti (School of Ecology & Environment, Warrnambool, Victoria, Australia); S.H. Vuurens (Wageningen Univ.); J. Boll (Univ. of Idaho, Moscow).

Vadose Zone Journal, Vol 5 No 4, p 1086-1092, Nov 2006

The authors present a technique to estimate from multi-compartment solute sampler (MCS) data whether a soil monolith is large enough to capture preferential flow, which is a necessity for tracer breakthrough curves to be representative. A reactor ratio of 0.665 is computed for a 300-compartment solute sampler covering an area of 0.75 sq m, compared with 0.04 for stochastic-convective and 1 for convective-dispersive transport. With a large single-cell collector, the reactor ratio would be 0.958, severely underestimating concentration variations.

## Rapid Analysis of Organophosphorus Pesticides in Soils

Casunuran, V.B., S.B. H. Bach, and D. Sarkar, Univ. of Texas at San Antonio.  
Environmental Geosciences, Vol 10 No 4, p 139-150, Dec 2003

An analytical methodology for directly analyzing organophosphorus pesticides in solid matrices was devised around a multi-gram capacity direct-insertion probe (DIP) interfaced to a quadrupole mass spectrometer (MS). The DIP-MS system was used to analyze acephate and diazinon in Ottawa sand. This system is capable of detecting 5 ug of acephate in the absence of an interfering matrix. For diazinon, the method detection limit was greatly reduced in soils other than the relatively pure Ottawa sand, likely due to the dilution effect of co-desorbing soil organic

matter; nonetheless, the DIP-MS technique shows the potential to analyze organophosphorus pesticides and other thermally extractable chemicals in soils and other solid matrices directly, without the need for solvent extraction, sample pretreatment, or confirmation by other analytical methods.

#### Rapid Identification and Area Delineation of Dispersed Chemicals Using a Surface-Sampling TOFMS, Ion Correlation Program, and Inexpensive Autosampler

Grange, A.H., R.J. Cody, and G. Sovocool.

Proceedings of the American Society of Mass Spectrometry, Seattle, WA, 28 May - 1 June 2006

To quickly gauge the dispersal of chemicals spread over solid surfaces (e.g., by an explosion) would require rapid sampling, detection (e.g., via mass spectrometry), and data processing. DART, a simple, inexpensive autosampler, can be used to process hundreds of samples per day. OA-TOFMS is an ion correlation program that can be used to determine ion and neutral loss compositions to identify or characterize analytes and to deconvolute mass spectra from multiple analytes using exact masses and RIAs.

<http://www.epa.gov/esd/pdf/ecb/ASMS06TalkPDF-202ecb06db.pdf>

#### The Relationship of Total Dissolved Solids Measurements to Bulk Electrical Conductivity in an Aquifer Contaminated with Hydrocarbon

Atekwana, E.A. and E.A. Atekwana (Univ. of Missouri-Rolla); R.S. Rowe (Purdue Univ.); D.D. Werkema Jr. (U.S. EPA, Las Vegas, NV); F.D. Legall (Gillette Company).

Journal of Applied Geophysics, Vol 56 No 4, p 281-294, 2004

A conceptual model links higher bulk conductivities at hydrocarbon contaminated sites to higher total dissolved solids (TDS) that result from enhanced mineral weathering due to acids produced during biodegradation. The authors evaluated the model by investigating the vertical distribution of bulk conductivity, TDS, and specific conductance in groundwater. Consistent with the model, higher TDS at contaminated locations were observed. Steep vertical gradients in bulk conductivity and TDS suggested vertical and spatial heterogeneity at the site. Based on the results of this study, the authors conclude that biodegradation processes can affect both electrolytic and surface conduction properties of contaminated sediments; these two factors can account for the higher bulk conductivities observed in hydrocarbon-contaminated sediments.

<http://www.epa.gov/esd//cmb/pdf/JAG-TDSpublished.pdf>

#### A Remote In Situ Monitor Based on Continuous Flow Analysis for the Quantitation of Sub-Micromolar Levels of Hexavalent Chromium in Natural Waters

Pressman, M.A.S. and J.H. Aldstadt III.

Journal of Environmental Monitoring, Vol 7 No 8, p 809-813, Aug 2005

A small, lightweight, deployable monitoring instrument has been developed for accurate measurement of parts-per-billion levels of hexavalent Cr in surface waters at hourly intervals. In continuous testing over a 15-day period, the results provided by the new instrument provided results that were in excellent agreement (<5% variation) with measurements made using an ICP-MS reference method.



## Remote Sensing and GIS in the Remediation of Chemical Weapons Contamination in an Urban Landscape

Slonecker, E.T. and S.R. Hirsch.

19th Annual Symposium of the United States Regional Association of the International Association for Landscape Ecology, Las Vegas, NV, 31 March - 1 April 2004

The American University in Washington, DC, was used by the Army during World War I as an experiment station for the development and testing of battlefield munitions, including chemical weapons such as mustard gas, phosgene, ricin, and lewisite. After the end of the war, many of the weapons and chemical agents were haphazardly buried in and around the American University testing area, now known as Spring Valley. In 1993, chemical-laden mortar shells were accidentally unearthed by a construction crew, setting off a series of investigations that, to date, have cost over 40 million dollars and continue still. The EPA/Environmental Photographic Interpretation Center is supporting the Superfund investigation efforts using a variety of spatial technologies, such as geographic information systems, historical aerial photo analysis, and hyperspectral remote sensing technology. Both conventional and research applications of remotely sensed imagery, along with GIS database developments, are playing a critical role in the discovery and removal of chemical weapons and contamination in this area. This presentation documents the use of historical imagery, GIS, photogrammetry, and hyperspectral remote sensing in locating and removing these weapons from the environment and establishing a risk assessment methodology for ongoing remedial activities.

## Report for 2005KS40B: A Real-Time Permittivity Sensor for Simultaneous Measurement of Multiple Water-Quality Parameters, Annual Report: March 1 - February 28, 2005

Zhang, Naiqian.

Kansas State University, 7 pp, 2006

The main objective of this project is to develop a novel, frequency-response-based permittivity sensor to detect and measure the concentrations of several types of pollutants in surface water and groundwater that are crucial to water quality. The sensor has a cascaded-electrode structure to enlarge the capacitive effect. The hardware includes a signal generator board, a gain and phase detector board, and a microcontroller to control the boards. Water samples with different combinations of soil sediment and salt (KCl) concentration levels were tested using a circulation system that provided uniform sediment concentrations. The sensor accurately measured KCl concentrations at each sediment concentration level. For sediment concentration measurement, the sensor only gave accurate measurement in water without added KCl and with KCl concentration of higher than 5,000 mg/L. For simultaneous measurement, the R-square values reached 0.86 and 0.87 for KCl and sediment, respectively. The sensor was also tested on diesel and biodiesel fuels. Distinct differences in frequency response patterns clearly indicate the potential of the sensor in examining the blending ratio between diesel and biodiesel. Kansas State University filed a provisional patent application for "Frequency-response sensors and associated signal conditioning/processing for real-time and simultaneous measurement of properties of dielectric materials" in the U.S. patent Office on March 8, 2006.

[http://water.usgs.gov/wrri/05grants/progress.completion\\_reports/KS/2005KS40B.pdf](http://water.usgs.gov/wrri/05grants/progress.completion_reports/KS/2005KS40B.pdf)

## A Review of the USEPA Methods for the Analysis of Perchlorate in Drinking Water in Drinking Water

Munch, D.J.; U.S. Environmental Protection Agency

Pepich, Barry V.; Shaw Environmental, Inc.

NEMC 2006: The 22nd Annual National Environmental Monitoring Conference, Arlington, Virginia, 28-31 August 2006

Four U.S. EPA methods have been published for the analysis of perchlorate in drinking water. A fifth, which employs Dionex's new 2-D technology, is being validated. The first method, EPA Method 314.0, supports a minimum reporting level (MRL) of 4.0 ug/L and was used during the first Unregulated Contaminant Monitoring Regulation (UCMR) cycle (2001-2005). Perchlorate concentrations above 4.0 ug/L were reported in approximately 4% of the public water systems tested. Based on these data, together with concerns regarding relative source contributions for perchlorate and available health effects data, EPA is considering whether perchlorate should be regulated in drinking water and/or if additional occurrence data needs to be collected at lower concentrations. To alleviate potential impediments associated with the availability of appropriate analytical methods, EPA's Office of Ground Water and Drinking Water (OGWDW) initiated method development projects that were aimed at developing new perchlorate methods that offer improved sensitivity, selectivity, and method robustness. A central goal was also to take full advantage of the available instrument base in the drinking water community, thereby offering the analytical laboratories the greatest flexibility in method selection. The new methods employ both ion chromatographic (IC) and liquid chromatographic (LC) separation, and detect perchlorate using either conductivity or mass spectrometric techniques. This paper describes all four OGWDW methods for the analysis of perchlorate in drinking water, specifically Methods 314.0, 314.1, 331.0 and 332.0, and introduces the fifth 2-D method. The most significant challenge remaining in the area of perchlorate analysis may be deciding which method to use.

<http://nemc.us/proceedings/2006/06T49ppt.pdf>

## Scenarios Evaluation Tool for Chlorinated Solvent MNA

Truex, M.J., C.J. Newell, B.B. Looney, and K.M. Vangelas.

WSRC-STI-2006-00096, Rev. 2, 194 pp Feb 2007

The 1998 EPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater and other technical protocols describe the technical basis for evaluating monitored natural attenuation (MNA) as a remedy. While MNA has been used successfully at hundreds of sites around the country, most of these protocols have the following limitations: (1) practitioners must decide on the level of detail and the information/analysis that is important to their specific site; (2) given the wide range of source, hydrogeologic, geochemical, and degradation processes that affect MNA studies, the application of the protocol can be complex; (3) existing classification schemes (such as Type 1, Type 2, Type 3 sites) are too limited; (4) many of the protocols are designed for sites where anaerobic biodegradation is the dominant natural attenuation mechanism, while natural attenuation at other types of sites is not addressed directly; and (5) key concepts related to natural attenuation can be difficult to communicate to stakeholders. This document uses a new approach to selecting or tracking the progress of MNA at chlorinated solvent sites. The approach presents a framework that links the MNA evaluation and associated decision logic to key site characteristics and known natural attenuation

phenomena. The approach is to take the wide spectrum of chlorinated solvent sites (e.g., different sources, hydrogeology, geochemistry, degradation process) and sort them into one of 13 different MNA scenarios. By applying a taxonomic system, the scenario that best describes a plume (or a segment of a plume) can be selected. The scenario contains information about how to proceed with MNA evaluation for the type of plumes that fit within the scenario.

[http://www.osti.gov/bridge/product.biblio.jsp?query\\_id=0&page=0&osti\\_id=899964](http://www.osti.gov/bridge/product.biblio.jsp?query_id=0&page=0&osti_id=899964)

#### Scene Analysis and Detection in Thermal Infrared Remote Sensing Using Independent Component Analysis

Foy, Bernard R. and James Theiler, Los Alamos National Laboratory, Los Alamos, NM. Independent Component Analyses, Wavelets, Unsupervised Smart Sensors, and Neural Networks II. Proceedings of SPIE--The International Society for Optical Engineering, Vol 5439, p 131-139, 2004

Independent Component Analysis (ICA) can be used to analyze cluttered scenes from remote sensing imagery and to detect objects. Examples in the thermal infrared spectral region (8-12 um) use both passive hyperspectral data and active multispectral data. The examples are from actual field data and computer simulations. ICA isolates spectrally distinct objects with nearly one-to-one correspondence with the independent component basis functions, making it useful for modeling the clutter in typical scenes. Examples of chemical plume detection in real and simulated data are provided.

<http://public.lanl.gov/jt/Papers/Foy-SPIE-04.pdf>

#### A Screening Approach to Simulation of Aquifer Contamination by Fuel Hydrocarbons (BTEX and MTBE)

Weaver, J.W. and R.J. Charbeneau.

Groundwater Contamination by Organic Pollutants: Analysis and Remediation. American Society of Civil Engineers, Reston, VA. ISBN: 0784405271, p 41-78, 2000

This chapter describes data from a set of LNAPL cases studies drawn from underground storage tank program files from state environmental agencies and the U.S. Department of Defense. These cases illustrate data availability under realistic conditions. Against this background, a simplified model for exposure assessment is described. This model is called the Hydrocarbon Spill Screening Model (HSSM). The mathematical basis of the model is given, and the underlying assumptions are discussed. Application of the model to a field site is described. This case has an extensive data set that was analyzed to generate input parameter values for the model. The approach included an estimate of mass of contaminants, the location of center of mass, and the gasoline volume. By treating the model inputs as fitting parameters, order-of-magnitude matches to these data sets were achieved. The model provides a means of completing the conceptualization of each site by providing a plausible source and transport scenario, which may not be directly observed from site data.

<http://www.epa.gov/nerl/mtbe/approach.pdf>

### The Self-Potential Method as a Non-Intrusive Redox Sensor in Organic-Rich Contaminant Plumes

Revil, A. CNRS-CEREGE, Europole de l'Arbois, Aix en Provence, France.

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS41A-07, 2006

Self-potential (SP) signals correspond to passively measured electrical potential anomalies at the ground surface that, once filtered, provide the signature of polarization processes occurring in the ground. The SP signals are provided by streaming potential related to the flow of the ground water and redox processes. Organic-rich contaminant plumes in the subsurface behave as natural geobatteries, creating an electrical field that can be measured at the ground surface and inverted to retrieve the geometry of the source and to determine the in situ redox potential in a non-intrusive way. The author discusses how the self-potential method can be used quantitatively as a non-intrusive redox sensor for investigating contaminant plumes and oil spills.

### Self Potential Observations during DNAPL Dissolution

Ntarlagiannis, D. and L. Slater (Rutgers Univ., Newark, NJ); B. Kulesa (Univ. of Wales, Swansea, UK); C. Russell (Nalco Ltd, Southampton, UK); R. Kalin and A. Ferguson (Queen's Univ., Belfast, UK); J. Graber (Purdue Univ., West Lafayette, IN).

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS41A-04, 2006

To evaluate the efficiency of geophysical methods to monitor dense nonaqueous-phase liquid (DNAPL) remediation, investigators performed self-potential (SP) measurements on laboratory columns packed with DNAPL-contaminated sand undergoing biodegradation and abiotic DNAPL dissolution. Geochemical monitoring showed higher concentration of dissolved DNAPL byproducts in the abiotic columns; the use of HgCl<sub>2</sub> as a biocide likely increased the rates of DNAPL dissolution in the abiotic columns. The concentration of DNAPL byproducts was significantly lower in the biotic columns due to consumption of breakdown products by DNAPL-degrading bacteria. SP responses were significantly higher in the abiotic columns, whereas SP values remained steady in the microbial-active columns. Although microbial activity in organic-rich contaminated areas has been associated with strong negative SP anomalies, results in this study show that positive SP anomalies can also be generated in contaminated areas in the absence of any microbial activity. The authors discuss a possible SP source mechanism and implications for geophysical monitoring of DNAPL remedial processes.

### Self-Potential (SP) and Active Electrical Geophysical Assessment of Bioremediation at a Contaminated Gasworks Plant

Kulesa, B., R.M. Kalin, R. Doherty, and D. Phillips.

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS34A-04, 2006

A former gasworks site in Portadown, Northern Ireland, was surveyed using self-potential (SP), electrical resistivity, induced polarization, and ground conductivity (EM-31, EM-34, EM-61). Installation of a permeable reactive barrier with groundwater flow control (slurry wall) was used with monitored natural attenuation to remediate contamination that included hydrocarbon and heavy metals at this complex site. The electrical geophysical surveys mapped the foundations of former infrastructure at the site and detected a formerly unknown tar well and a pit filled with mixed waste. The authors investigated the relationship between residual SP and

redox potential measured in several successive contaminated aquifer layers separated by aquitards and examined the SP and electrical geophysical signatures of microbial processes naturally degrading the subsurface contaminants. This paper presents preliminary findings from SP and electrical geophysical monitoring of artificially disturbed microbial processes and subsurface redox conditions.

### Separation of Colloidal Particles from Groundwater by Cross-Flow Electro-Filtration Process for Improving the Analysis of Lead (Year III)

Huang, C.T. and Y.T. Lin, Univ. of Delaware.

New Jersey Department of Environmental Protection, 194 pp, July 2004

Lead (Pb) in the soil-water system is mostly associated with solid particulates, especially colloids, which covers particle size from 0.01 to 10  $\mu\text{m}$ . Because the particulate material is small, it is easily disturbed and often introduced into water samples during sampling operations, especially in new monitoring wells, as the particulates are unstable and abundant. The presence of fine particulates in water samples of monitoring wells can trigger unnecessary site investigation. NJDEP (New Jersey Department of Environmental Protection) has used a low-flow purging technique to minimize the introduction of particulates in groundwater samples. Though effective, this technique is slow (with a pumping rate of 0.5 to 5 mL/min) and therefore expensive. Filtration is another way to separate the soluble from the insoluble (particulates) fraction of Pb in groundwater samples, but the filter (currently only 0.45  $\mu\text{m}$  filters are used) may collect the colloidal materials, which not only excludes the naturally occurring colloids in the analysis of Pb in groundwater, but also causes difficulties in filtration. Research was conducted to develop an innovative solid/liquid separation technique for the determination of heavy metal (i.e., Pb) in groundwater. The technique should be capable of separating the naturally occurring colloids into several size fractions with ease. The following were specific objectives. (1) Design and operate a crossflow electro-filtration (CFEF) process for the separation of naturally occurring colloids from groundwater. An instrument based on the principle of the CFEF process to be constructed and operated. The CFEF unit to eliminate all problems associated with conventional dead-end filtration process. (2) Study the major factors controlling the operation of the crossflow electrofiltration process. Factors such as filtration rate, applied field strength, influent water quality, membrane type, and characteristics that may affect the performance of the CFEF unit to be evaluated. Performance of the CFEF process to be assessed in terms of effluent quality, rejection, flux rate, and backwash. (3) Study the use of the CFEF as a means to improve Pb determination in groundwater. The effectiveness of the CFEF process on Pb speciation to be compared with low-flow-purging technique and conventional bailer sampling. This report provides the study results, yielding insight into the performance and the separation mechanism of the CFEF module and Pb speciation in groundwater. There is great potential to replace current slow-purging technique with this CFEF process in groundwater monitoring in the context of site remediation, though further improvement of the CFEF module and continued data collection are needed before the system can be fully deployed. Earlier reports from this project are available at <http://www.state.nj.us/dep/dsr/publications/pub.htm> <http://www.state.nj.us/dep/dsr/wq/Pb%20electrofiltration%20-%20year%2003.pdf>

SERDP and ESTCP Expert Panel Workshop on Reducing the Uncertainty of DNAPL Source Zone Remediation

Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP). 198 pp, Sep 2006

At a workshop sponsored by SERDP and ESTCP in March 2006 in Baltimore, MD, over 40 expert participants sought to determine the research, development, test, and evaluation needs for reducing the uncertainty associated with dense nonaqueous phase liquid (DNAPL) source-zone remediation at field sites. The exercise was intended to define a path forward to reduce the uncertainty surrounding source-zone cleanup of DNAPL sites by reviewing (1) the progress to date, including a consensus perspective on the implications of the funded research for practical remediation, (2) the current state of the science, and (3) the remaining data gaps. This report identifies, defines, and prioritizes DoD's future research and demonstration needs for cleanup of DNAPL source zones. Key issues associated with characterization of DNAPL source zones include (1) defining the level of characterization required, (2) assessing source function, (3) increasing cost-effectiveness of tools, (4) understanding the impact of vadose zone processes, and (5) integrating site characterization and remediation. Key issues associated with remedial endpoints and long-term monitoring include (1) transition from aggressive treatment to long-term monitoring, (2) reduction of long-term monitoring costs, and (3) how (or if) to use mass flux.

<http://www.estcp.org/Technology/ER-Chlorinated-Solvents.cfm>

SERDP and ESTCP Expert Panel Workshop on Research and Development Needs for the Environmental Remediation Application of Molecular Biological Tools

Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP), 64 pp, Oct 2005

A workshop was sponsored in August 2005 by SERDP and ESTCP to determine the research, development, test, and evaluation needs for molecular biological tools that have the potential to improve the design, implementation, performance, and monitoring of remediation technologies in the field. To communicate the state of the science and engineering associated with current molecular biological tools and techniques, potential future applications of tools, and field use and considerations, background papers were written and presented at the workshop by experts in these areas. The meeting identified the following needs areas. Research needs: sampling techniques, identification of additional biomarkers, correlation of detection or quantification of biomarkers with degradation rates, understanding of microbial interactions, and systems biology approaches. Demonstration needs: standardization and validation of methods used to extract biomarkers, application of tools across multiple field sites for chlorinated ethenes, and incorporation of molecular biological tool data into models that demonstrate and predict bioremediation performance or failure in the field. Technology transfer needs: Web-based resources for sharing information and data, as well as education, guidance, and standardization of approaches among stakeholders. The result of this workshop is a strategic plan to guide SERDP and ESTCP investments in molecular biological tools over the next 5 to 10 years.

<http://docs.serdp-estcp.org/viewfile.cfm?Doc=MBT%20Workshop%20Report%2Epdf>

### A Simple and Effective Water Sampling Technique for Mercury in Surface Waters

McCrea, Robert, Environment Canada.

Eighth International Conference on Mercury as a Global Pollutant, Madison, Wisconsin, 6-11 August 2006

The ISOMET, an innovative water sampling technique, was compared to a GO-FLO sampler used in conjunction with vessel-based clean-room technologies for the determination of mercury in waters of the Great Lakes. The ISOMET system utilizes a simple isolation strategy throughout the monitoring process for preparation, transportation, sampling, and analyses. In the field, a PFA container mounted onto the ISOMET sampler is opened and closed under water, limiting exposure to the water being sampled. The ISOMET container serves as both sampling vessel and sample bottle and, when used for trace metal sampling, as the closed digestion vessel and the ICP-MS auto-sampler tube. This device eliminates exposure in the field and sample transfers in both the field and laboratory. Essentially identical mean whole-water mercury concentrations were obtained from replicate samples collected with the GO-FLO and ISOMET-EL samplers mid-lake in Lake Ontario. A survey of 10 of these open-water sites revealed little spatial variation in mercury concentrations. The results demonstrate that representative mercury samples can be collected without the expense of in-field clean-room facilities. The lightweight ISOMET samplers are robust, simple to use, and quick (5-min sample collection), and they can be used for both ultra-trace and contaminated site sampling. The ISOMET has been adopted by Environment Canada and the Ontario Ministry of the Environment for mercury and trace metal sampling in the Great Lakes and their connecting channels.

### A Simplified Method for Estimation of Jarosite and Acid-Forming Sulfates in ARD Wastes

Li, J. and R. Smart (Univ. of South Australia, Mawson Lakes, SA, Australia); R. Schumann and G. Levay (Levay and Co. Environmental Services, Mawson Lakes, SA, Australia).

2006 SME Annual Meeting and Exhibit & 7th ICARD, March 26-29, 2006, St. Louis, Missouri. American Society of Mining and Reclamation (ASMR), Lexington, KY. p 458-475, 2006

A fast and effective site method to quantify acid sulfate salts such as jarosite and ferrous salts for more accurate estimation of maximum potential acidity has been developed and tested on synthetic and real wastes. An acid sulfate soils method has been modified for sulfide wastes. The extraction procedure requires the following sequence: (1) argon-purged water extraction (3 min) for soluble Fe(II) salts, epsomite, and gypsum, (2) 1 M KCl extraction (4 h) for higher contents of gypsum and epsomite; 3) roasting at 550 degrees C (1 h) to remove pyrite and reactive sulfides; and 4) 4 M HCl extraction (16 h) for jarosite extraction. The procedure quantitatively determined melanterite, epsomite, gypsum, pyrite, and jarosite concentrations (5 wt % each) in a synthetic waste with quartz. It is possible to remove step 2 if gypsum and epsomite content is low and replace step 4 by a solid assay for S.

### Simultaneous Measurement of Specific Discharge and Cr(VI) Mass Flux in Porous Media Using Permeable Adsorbent Device

Campbell, Timothy J., Kirk Hatfield, and Michael D. Annable, Univ. of Florida, Gainesville. AFRL-ML-TYTR-2004-4527, 32 pp, 2004

The authors propose a method for simultaneous measurement of local groundwater-specific discharge ( $q$ ) and Cr(VI) mass flux ( $J(\text{Cr})$ ) using a permeable adsorbent device. The method allows for determination of both  $q$  and  $J(\text{Cr})$  as 2-D vectors, with each vector composed of an angular ( $q(\theta)$ ,  $J(\theta)(\text{Cr})$ ) and a radial ( $q(r)$ ,  $J(r)(\text{Cr})$ ) component. The device

consists of a cylindrical container whose outer shell is constructed of highly permeable mesh material with impermeable end caps. The interior of the device is divided into a center well and three outer sectors, each packed with a granular anion-exchange resin having high adsorption capacity for the Cr(VI) oxyanions  $\text{CrO}_4^{2-}$  and  $\text{HCrO}_4^-$ . The adsorbent in the center well of the device is loaded with berizoate as resident tracer. Experiments were conducted in which these devices were placed in porous packed-bed columns through which was passed a measured quantity of simulated groundwater containing Cr(VI). The resin was then removed from the four sectors separately and extracted to determine the masses of Cr(VI) and resident tracer bound in each. A linear solute transport model was used to relate the observed rate of resident tracer displacement to  $q(\theta)$  and  $q(r)$ , and a simple mass balance equation was used to calculate  $J(r)\text{Cr}$ . Experimental results showed  $q(\theta)$  was measured to an accuracy of  $\pm 1$  degree. Accuracy of the radial specific discharge vector component depended on the degree of displacement of the resident tracer.  $J(r)\text{Cr}$  mass flux vector radial component was measured to an accuracy of  $\pm 17\%$ . These results demonstrate that the proposed method represents a promising technique for determination of specific discharge and contaminant mass flux in contaminated aquifers.

<http://handle.dtic.mil/100.2/ADA423922>

#### A Small Subsurface Ion Mobility Spectrometer Sensor for Detecting Environmental Soil-Gas Contaminants

Kanu, Abu B., Herbert H. Hill, Jr, Molly M. Gribb and Robert N. Walters  
Journal of Environmental Monitoring, Vol 9 No 1, p 51-60, Jan 2007

A small subsurface ion mobility spectrometer (SS-IMS) was constructed and tested with several environmental contaminants to determine its potential for monitoring gaseous volatile organic compounds, such as TCE and PCE, in the vadose zone. The instrument yielded detection limits as low as 1 part per billion volume-to-volume.

#### Sorptive Extraction Techniques for Trace Analysis of Organic Pollutants in the Aquatic Environment

Buchberger, Wolfgang and Pola Zaborsky, Johannes-Kepler-Univ. Linz, Linz, Austria.  
Analytica Chimica Slovenica, Vol 54 No 1, p 1-13, 2007

The authors review the current state of sorptive extraction for organic trace analysis of water samples, discussing both the theoretical aspects and applications for organic xenobiotics in the aquatic environment. The ongoing acceptance of sorptive extraction techniques into official methods indicates that the techniques offer satisfactory reliability and robustness for routine monitoring purposes.

<http://acta.chem-soc.si/54/54-1-1.pdf>

#### Species Analysis During Measurements Process

Bath, F., M. Batzke, and T. Fahrenholz (Retsch, Inc.); J. Kern and K.M. "Skip" Kingston (Duquesne Univ.); M. Pamuku (Retsch, Inc.); M. Rahman (Duquesne Univ.).  
NEMC 2006: The 22nd Annual National Environmental Monitoring Conference, Arlington, Virginia, 28-31 August 2006

Elemental speciation is unique in that the species of interest or the analyte being evaluated may change and become another analyte during the analysis process. This phenomenon and related parameters make species measurement exceptionally challenging,



especially when the goal is to achieve accuracy. Significant areas contributing to the lack of accuracy are the lack of certified standard materials and the lack of proven, reliable diagnostic tools. Many elemental species undergo conversion or degradation of the species of interest during measurement processes and even sometimes during sampling, storage, and transport. Until recently, there has been no effective diagnostic tool to trace the fate of species; conventional speciation methods measure the species' concentrations in the final solutions at the time of measurement but provide no information on species transformations. Knowing the transformation of the species is critical in the preparation and certification of standard reference materials and for accurate speciated measurements. Newly approved EPA RCRA Method 6800, Speciated Isotope Dilution Mass Spectrometry (SIDMS), facilitates the identification and correction of such degradations or conversions. SIDMS can also be directly applied to validate a variety of other speciated protocols to measure species like methylmercury, ethylmercury, and other alkylmercury species accurately in tissues and other materials. SIDMS has been demonstrated to determine the species concentrations at the time of spiking, as well as during sampling and measurement processes. The method also provides the ability to perform diagnostic analysis by isolating procedural protocol steps in specific matrices and reveal species shifting potential. By spiking the sample at multiple steps with enriched stable isotopes of the same species, SIDMS can identify the steps at which the species are altered. SIDMS has been applied to monitoring the fate of methylmercury and Hg(II) and other alkylmercury species, as well as Cr(III) and Cr(VI), during the sample processing and analysis steps. This extended abstract is accompanied by a presentation with a different title, "Achieving Quantitative Species Analysis When Analytes Turn Into Other Analytes During the Measurement Process," at <http://nemc.us/proceedings/2006/06T46ppt.pdf>.  
<http://nemc.us/proceedings/2006/06T46pa.pdf>

Standard Guide for Collecting Treatment Process Design Data at a Contaminated Site: A Site Contaminated With Chemicals of Interest: ASTM D7294-06  
American Society for Testing and Materials (ASTM International), Vol 11.04, 2006

This guide lists the physical and chemical treatment processes design data needed to evaluate, select, and design treatment processes for remediation of contaminated sites. Much of these data can be obtained and analyzed at the site with instruments and test kits. Use of this guide is recommended in conducting environmental site assessments and remedial investigations/feasibility studies (RI/FS) and selections of remedy in U.S. Code of Federal Regulations 40 CFR 300.430.

Statistical Assessment of Contaminated Land: Some Implications of the Mean Value Test  
CL:AIRE Technical Bulletin 12, 4 pp, Nov 2006

Statistical methods are commonly used to guide decision-making in many regulatory contexts. For the assessment of potentially contaminated land, it is common practice to use the mean value test approach defined in Appendix A of Contaminated Land Report 7 (DEFRA and Environment Agency, 2002). This bulletin suggests alternative techniques to reduce the risk of underestimating the true 95% upper confidence limit of the sample mean.  
[http://www.claire.co.uk/pdf\\_usr/tb12\\_stats\\_final.pdf](http://www.claire.co.uk/pdf_usr/tb12_stats_final.pdf)

Studies of the Cataluminescence of Benzene Homologues on Nanosized gamma-Al<sub>2</sub>O<sub>3</sub>/Eu<sub>2</sub>O<sub>3</sub> and the Development of a Gas Sensor for Benzene Homologue Vapors

Lu, J., X. Cao, C. Pan, L. Yang, G. Lai, J. Chen, and C. Wu, Guangzhou Univ., China. Sensors, Vol 6 No 12, p 1827-1836, Dec 2006

The cataluminescence (CTL) of benzene and its homologues (i.e., toluene and xylenes) on nanosized gamma-Al<sub>2</sub>O<sub>3</sub> doped with Eu<sub>2</sub>O<sub>3</sub> (gamma-Al<sub>2</sub>O<sub>3</sub>/Eu<sub>2</sub>O<sub>3</sub>) was studied to design a sensor for determining these gases. The sensor showed high sensitivity and selectivity at an optimal temperature of 432 degrees C, a wavelength of 425 nm, and a flow rate of 400 mL/min. Quantitative analysis was performed at the optimal conditions. The linear ranges of CTL intensity versus concentration of the benzene homologues were 2.4~5000 mL/m<sup>3</sup> for benzene, 4.0~5000 mL/m<sup>3</sup> for toluene, and 6.8~5000 mL/m<sup>3</sup> for xylene, with detection limits of 1.8 mL/m<sup>3</sup>, 3.0 mL/m<sup>3</sup>, and 3.4 mL/m<sup>3</sup>, respectively. The response time of this system was less than 3 seconds. The presence of other gases--SO<sub>2</sub>, CO, and NH<sub>3</sub>--caused interference at levels around 11.7, 5.8, and 8.9% respectively. The technique is a fast and convenient way to determine the vapors of benzene homologues in air.

<http://www.mdpi.org/sensors/papers/s6121827.pdf>

Technology News and Trends

U.S. EPA, Mar 2007

This issue focuses on sediment sampling and presents 4 brief articles on the following subjects: a new sampler that minimizes disturbance during sediment collection; a combined benthic test that determines metal and organic flux rates in marine sediment; the addition of ELISA to the Rapid Screening Characterization Toolbox; and integration of porewater and geophysical investigations to streamline characterization of ground-water discharges to surface water.

<http://www.clu-in.org/products/newsletters/tnandt/>

Time-Lapse Electrical Resistivity Characterization of LNAPL Pollution in a Clayey-Sand Formation

Adepelumi, A.A., A.A. Solanke, O. Sanusi, and H. Ogundipe.

SAGEEP 2006: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 2-6 April 2006, Seattle, WA. Geophysical Applications for Environmental and Engineering Hazards--Advances and Constraints. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, 2006

A time-lapse electrical resistivity experiment was conducted in a model simulation tank to monitor the migration of light nonaqueous-phase liquid (LNAPL) pipeline leakage. Two-dimensional modeling was used to simulate LNAPL behavior in the contaminated zone. The models produced markedly different anomaly shapes for a conceptual model of the development of the contaminant plume. A dipole-dipole array best resolved the hydrocarbon (resistor) embedded in a moderately conductive medium and hence was adopted for electrical resistivity laboratory studies. The laboratory study results indicated that a resistivity increase a few hours after injection is likely related to LNAPL accumulation in the vadose zone. All the inverted tomographic sections confirm the presence of a resistive layer at a depth of 0.2 m, extending

down to 0.4 m. An observed decrease in resistivity of the hydrocarbon suggests modification of the cation exchange capacity of the soil mixture due to biodegradation of the hydrocarbon.

#### Total Cyanide Without Distillation

Lipps, William, OI Analytical.

NEMC 2006: The 22nd Annual National Environmental Monitoring Conference, Arlington, Virginia, 28-31 August 2006

Cyanide (CN<sup>-</sup>) forms complexes with most metals, and methods for the determination of cyanide are defined by the relative strength of the metal complexes. The species of cyanide present in a water sample is determined by pH, the presence of oxidizers, the presence of transition metals (and which transition metals), and the presence of sulfur and sulfur compounds. The methods for the determination of cyanide are defined by an attempt to measure the various cyanide species. Free cyanide is defined as the amount of HCN liberated from a buffer solution adjusted to the pH of the receiving stream. A new method is based on OIA Method 1677 and ASTM D6888, "Ligand Exchange Flow Injection-Gas Diffusion Amperometric Methods for Determination of Available Cyanide." Instead of ligands, metal cyanide complexes are broken up by UV irradiation. The method determines the same cyanide species as total cyanide by distillation, yielding results in minutes instead of hours. This simplified method does not suffer from as many interferences as currently approved methods. As cyanide complexes release cyanide after UV irradiation, the hydrogen cyanide formed diffuses into a dilute NaOH stream, and cyanide is determined amperometrically. Less than one milliliter of sample is required, and very little hazardous waste is generated.

<http://nemc.us/proceedings/2006/06T34ppt.pdf>

#### An Updated Model for the Anomalous Resistivity of LNAPL Plumes in Sandy Environments

Sauck, W., E. Atekwana, and D.D. Werkema.

Eos: Transactions of the AGU, Vol 87 No 36, Jt. Assem. Suppl., Abstract NS41A-08, 2006

Since 1997, anomalously low resistivities have been observed at some sites contaminated by light nonaqueous phase liquid (LNAPL). A conductive model used to explain this phenomenon was published in 2000. The working hypothesis in the conductive model invokes both physical mixing and bacterial action to explain the low resistivities near the base of the vadose zone and the upper part of the aquifer. Organic acids and carbonic acids produced by hydrocarbon-degrading bacteria filter into pore waters and dissolve readily soluble ions from the native soil grains and grain coatings, producing a leachate high in total dissolved solids. This update introduces new aspects of the conductive model. (1) In addition to acids, the oil-degrading bacteria produce surfactants that detach the oil phase from the solid substrate and form an emulsion of oil droplets within the water. This phenomenon provides passage for electrical current during electrical resistivity measurements. The addition of organic acids and biosurfactants to pore fluids also can contribute directly to the conductivity of the pore fluids. (2) A 2-year set of column experiments with diesel oil has shown that the resistivity decreases, the TDS of water samples increases, and a radical change in bacterial populations favoring the oil degraders occurs. Most of the significant changes occurred in 4 to 6 months in the laboratory. (3) Certain bacteria (e.g., *Geobacter sulfurreducens*) exhibit hairlike structures (pili) that are excellent electrical conductors. These pili, which are longer than the bacterial body itself, are

apparently used like nanowires for electron transfer by the bacteria. Large numbers of bacteria could conceivably alter the electrical resistivity of a volume of earth.

#### Use of a Nafion Membrane Probe for Quick, On-the-Spot Determination of Ionic Copper Contamination Levels in Natural Waters

Foerster, John and Robert LaMontagne.

Strategic Environmental Research and Development Program (SERDP), Project 1160, 54 pp,

The objective of this project was to develop an operationally simple, user-friendly detection system for rapid assessment of the major ionic copper ions in the marine environment. Emphasis was placed on ionic copper species [e.g., Cu(I) and Cu(II)] that could adversely affect the marine environment biota. The overall goal of the project was to develop and test an ionic copper probe that had parts per billion (ppb) detection limits and could be used easily by personnel having little to no formal chemistry analysis training. The Nafion Membrane Probe uses a polymer impregnated with a color indicator. The polymer was impregnated with a Cu(I) metal ion organic complexing agent, 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (Bathocuproine or BCP), and attached to a plastic panel. BCP reacts with Cu(I) to give a very intense, visible, and stable orange-complex with a unique spectroscopic signal. The probe can be immersed in a known volume of water suspected to contain Cu(I). When the probe is removed from the solution and the active test strip is compared to a known color concentration panel, a relative concentration of Cu(I) is determined. Cu(II) can be measured by adding a reducing agent to the sample before introducing the probe.

<http://docs.serdp-estcp.org/viewfile.cfm?Doc=CP%2D1160%2DFR%2D01%2Epdf>

#### The Use of a Thermogravimetric Analyzer for the Generation of Primary Analytical Vapor Standards of Organophosphate Pesticides

Boyd, J.W., C.K. Eckman, N.A. Romero, S.S. Ramkumar, and G.P. Cobb.

Analytica Chimica Acta, Vol 558 Nos 1-2, p 35-41, 2006

A thermogravimetric analyzer (TGA) was used for the generation of primary vapor standards of three organophosphate pesticides encompassing a wide range of vapor pressures. The technique combines a dynamic flow-through evaporation system with gravimetric analysis of weight loss from an analyte reservoir. Vapor reference standards can be produced in less than 1 h per compound, including purging the system between compounds. This sensitive (ppm to ppb), fast, robust (compounds with vapor pressures spanning five orders of magnitude), low-consumption, and extremely general technique can be used for the generation of numerous vapors in a variety of concentrations and quantities.

#### The Use of Geophysical Investigation Techniques in the Assessment of Contaminated Land and Groundwater

CL:AIRE Technical Bulletin 5, 4 pp, Jan 2007

At contaminated sites, geophysical investigations can be applied at the ground surface (non-invasive), within existing boreholes or cased wells, or during direct push drilling. Each mode of application characterizes the relevant property at a different scale and is capable of different resolution; choosing an approach is at least partly a function of the purpose of the

investigation. For example, non-invasive techniques are most often used to obtain a site-scale picture of general lithology and shallow subsurface features that can help plan more focused invasive data collection. Techniques applied in boreholes or cased wells (i.e., rock or existing monitoring wells) and those involving direct push (unconsolidated sediments) sample at a smaller scale but offer greater resolution. Common to most geophysical methods is the collection of raw electrical or acoustic signal data that must be processed and converted through some form of calibration to allow interpretation. Data processing generally requires specialized software and a certain degree of expertise or experience. Also common to all geophysical methods is the need to ensure that the property being characterized is calibrated against a known standard. For example, a sediment core log should be used to calibrate lithology, contaminant concentrations for plume mapping, or residual saturation for Nonaqueous-phase liquid (NAPL) mapping. This bulletin describes the use of geophysical investigation techniques in the assessment of contaminated land and groundwater in the United Kingdom.

[http://www.claire.co.uk/pdf\\_usr/tb5\\_geophysics\\_finalweb.pdf](http://www.claire.co.uk/pdf_usr/tb5_geophysics_finalweb.pdf)

#### The Use of In Situ Measurement of Hydraulic Conductivity to Provide an Understanding of Cover System Performance over Time

Meiers, G. (O'Kane Consultants, Saskatoon, SK, Canada); L. Barbour (Univ. of Saskatchewan, Saskatoon, SK); C. Qualizza (Syncrude Canada, Ft. McMurray, AB).

2006 SME Annual Meeting and Exhibit & 7th ICARD, March 26-29, 2006, St. Louis, Missouri. American Society of Mining and Reclamation (ASMR), Lexington, KY. p 1259-1272, 2006

Three cover systems were constructed in 1999 on a salinesodic shale overburden fill at the Syncrude oil sands mine in Fort MacMurray, AB, Canada. The covers are designed to provide adequate moisture storage for vegetation while minimizing the impact of salt release from the underlying waste material. The hydraulic performance of the covers was evaluated through repeated testing of in situ hydraulic conductivity (K) over time, and the changes were related to changes in monitored interflow collection rates. The mean K of the cover material increased approximately 2 orders of magnitude during the first 3 years following placement and then remained relatively constant. The interflow collection volumes have increased each year, with the magnitude of interflow offset from the measured K values by 2 to 3 years.

#### The Use of Semipermeable Membrane Devices as Passive Samplers to Determine Persistent Organic Compounds in Indoor Air

Strandberg, B., P. Gustafson, H. Soderstrom, L. Barregard, P.-A. Bergqvist, and G. Sallsten. Journal of Environmental Monitoring, Vol 8 No 2, p 257-262, Feb 2006

The convenience of semipermeable membrane device (SPMD) technology facilitates its use for semi-quantitative screening and monitoring of various persistent organic compounds in buildings. SPMDs were used to sample 28 PAHs and 19 PCBs in the gas phase in 15 single-family houses located in an area in Sweden where domestic wood burning is common. Eight households used wood-burning appliances; the others used other systems for residential heating. Most of the studied compounds were detected in the houses: the PAHs at levels similar to or slightly higher than published SPMD-sampled levels for background or urban sites in Sweden, and the PCBs at levels slightly lower than those found in both indoor and outdoor urban

locations. Wood-burning heating systems may contribute to PAHs in indoor air, and sources can be indoor emissions or penetration from outdoors.

#### The Use of Spatial Analytical Techniques to Identify Potential Brownfields Sites

Tilley, J.S., R. Paul, E. Slonecker, and E. Walkowiak.

Rates, Trends, Causes, and Consequences of Urban Land-Use Change in the United States.

U.S. Geological Survey Professional Paper 1726, p , 2006

Brownfields are abandoned, idled, or underutilized properties where expansion or redevelopment is complicated by real or perceived environmental contamination. Most brownfields sites are located in urban, commercial, and industrial areas. Under the Brownfields Program, U.S. EPA provides grants, technical assistance, and liability relief to encourage the remediation and/or redevelopment of these properties. One of the key information requirements in any successful brownfields program is the ability to identify and inventory potential brownfields sites. Because the current alternatives of ground-based surveys, informal real-estate listings, or general perceptions are time consuming and unreliable, spatial information technologies might play a critical role in providing this inventory of potential sites. The authors used spatial analytical techniques and diverse GIS datasets to identify potential brownfields sites over a city-wide area efficiently and quickly. A defensible and repeatable geographic methodology will benefit any community in identifying properties that could be potentially returned to higher and better uses. With such an application, cost savings could be applied in the other processes of Brownfields revitalization or urban redevelopment.

<http://pubs.usgs.gov/pp/pp1726/>

#### Use of the p,p'-DDD:p,p'-DDE Concentration Ratio to Trace Contaminant Migration from a Hazardous Waste Site

Pinkney, A.E. and P.C. McGowan, U.S. Fish and Wildlife Service, Annapolis, MD.

Environmental Monitoring and Assessment, Vol 120 Nos 1-3, p 559-574, Sep 2006

Hazardous wastes are known to have been disposed of in an 11-hectare area of the Old Landfill at Marine Corps Base Quantico, VA. Polychlorinated biphenyls (PCBs) and DDT compounds migrated into the sediments of the Quantico Embayment along the Potomac River. The authors interpreted total PCB (t-PCBs) and total DDT (t-DDT, sum of six DDT, DDD, and DDE isomers) data from monitoring studies, using the ratio of p,p'-DDD to p,p'-DDE concentrations in carp and killifish as a tracer to distinguish site-related from regional contamination.

#### Using Bioassays to Determine Potential Toxicity of Mine-Waste Leachates

Choate, L. (US Geological Survey, Denver, CO); J. Ranville (Colorado School of Mines, Golden); K. Smith (US Geological Survey, Denver, CO). 2007 SME Annual Meeting & Exhibit and 109th National Western Mining Conference, February 25-28, 2007, Denver, Colorado: Abstracts.

Mine-waste leachates are assumed to be toxic to aquatic organisms if pH is less than five, but toxicity is uncertain and must be tested if pH is greater than five. Standard aquatic toxicity tests are conducted by culturing aquatic organisms such as *Ceriodaphnia dubia* and exposing

them to the leachate. These tests are expensive and time intensive. An alternative method, the enzymatic assay MetPLATE, was compared against the 48-hour *C. dubia* acute toxicity test. Additionally, *C. dubia* ehippia, a dormant form that is re-hydrated just prior to the test, was compared against fresh *C. dubia* stock cultures maintained in the laboratory.

#### Using the Stress Response to Monitor Process Control: Pathways to More Effective Bioremediation

Hazen, T.C. and D. Stahl.

Current Opinion in Biotechnology, Vol 17 No 3, p 285-290, 2006

The development of stress response systems may provide tools for effective bioremediation monitoring and general process control. Within an environmental context, (i.e., in the field) microorganisms are constantly exposed to multiple changing environmental stresses, and work must be undertaken to gain full understanding of microbial adaptive resiliency in that context in order to facilitate the control of bioremediation and other processes mediated by complex microbial communities.

#### UV Spectroscopic Monitoring of Vaporized Monoaromatic Hydrocarbons from Petroleum-Contaminated Soils

Kim, W.J. (Ewha Womans Univ., Seoul, Korea); J.I. Lee (Korea Research Inst. of Standard and Science, Daejeon); S. Lee and K.-H. Ahn (Korea Inst. of Science and Technology, Seoul); J.-W. Park (Hanyang Univ., Seoul).

Environmental Monitoring and Assessment, Vol 120 Nos 1-3, p 527-536, Sep 2006

The authors discuss the use of ultraviolet (UV) absorbance for on-line monitoring of vaporized monoaromatic hydrocarbons from petroleum-contaminated soils. In the fixed system (which exhibited higher sensitivity than the portable one), the absorbance intensity of benzene, toluene, ethylbenzene, and xylenes (BTEX) increased in proportion to the concentration of the contaminants. The portable system, though less sensitive, exhibited faster response and was suitable for screening purposes. Water was not an interferent.

#### Validation of Methods to Measure Mass Flux of a Groundwater Contaminant

Yoon, Hyouk, Master's thesis, Air Force Inst. of Technology, Wright-Patterson Air Force Base. AFIT/GES/ENV/06M-08, NTIS: ADA445057, 62 pp, Mar 2006

Flux measurements obtained using two methods were compared with known mass fluxes in a meso-scale three-dimensional artificial aquifer. One method, the tandem recirculating well (TRW) method, was applied using two different techniques. One technique is simple and inexpensive, only requiring measurement of heads, while the second technique requires conducting a tracer test. The second method, the integrated pump test (IPT), requires use of one or more pumping and observation wells in various configurations. The results of the experiments in the artificial aquifer show that the most expensive technique, the TRW method using tracers, provides the most accurate results (within 15%). The TRW method that relies on head measurements is very inaccurate, so the technique appears not to be viable for flux measurement. The IPT method, although not as accurate as the TRW method using the tracer technique, does produce relatively accurate results (within 60%). IPT method inaccuracies appear to be due to the fact that the method assumptions were not well-approximated in the artificial aquifer. While

measured fluxes consistently underestimated the actual flux by at least 36% and as much as 60%, it appears that errors may be reduced when potential violations of method assumptions are taken into account.

<http://handle.dtic.mil/100.2/ADA445057>

Validation of Thin-Layer Chromatographic Methods for Pesticide Residue Analysis  
International Atomic Energy Agency, Vienna. ISBN: 92-0-108205-3, IAEA-TECDOC-1462,  
236 pp, July 2005

Thin-layer chromatography (TLC) was widely used in the 1960s and 1970s for pesticide residue analysis, but only to a limited extent since gas/liquid chromatography (GLC) and high-performance liquid chromatography (HPLC) have become readily available. In recent years, there have been various developments in the quality of plate coating and in detection systems, as well as in extraction and cleanup methods, that make it possible to apply TLC according to the current international quality standards. The TLC methods described in this publication are intended for laboratories where irregular supply of electricity, lack of service, or limited budget do not allow continuous use of GLC and HPLC techniques, and where application of mass spectrometric detection is not feasible. TLC analytical techniques allow for screening, semi-quantitative determination, and confirmation of pesticide residues and other organic trace contaminants and have only minor requirements on equipment and laboratory infrastructure. TLC methods are therefore particularly suitable for laboratories working with limited budgetary resources. The papers that comprise this volume address a range of pesticide residues.

[http://www-pub.iaea.org/MTCD/publications/PDF/te\\_1462\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/te_1462_web.pdf)

Vapor Intrusion Pathway: A Practical Guideline  
Interstate Technology & Regulatory Council (ITRC) Vapor Intrusion Team.  
Report No VI-1, 172 pp, Jan 2007

This document is a practical how-to guide for assessing the vapor intrusion pathway that allows gas-phase volatile organic compounds to seep into buildings. Supplemental information is contained in appendices and in a companion document, "Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios." This text contains an overview of vapor intrusion and covers preliminary screening of sites, site investigation, and mitigation. Due to variations in policy amongst regulatory agencies, this document does not provide a single prescriptive approach for assessing the vapor intrusion pathway. Instead, the purpose of the guideline is to provide a generalized framework for evaluating the pathway and a description of the various tools available for investigation, data evaluation, and mitigation. The guideline is intended to be used in conjunction with any applicable federal or state vapor intrusion policy or guidance.

<http://www.itrcweb.org/Documents/VI-1.pdf>

Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios -- A Supplement to  
Vapor Intrusion Pathway: A Practical Guideline  
Interstate Technology & Regulatory Council (ITRC) Vapor Intrusion Team.  
Report No VI-1A, 52 pp, Jan 2007

This supplement should be used in conjunction with ITRCs 2007 "Vapor Intrusion Pathway: A Practical Guideline." Many vapor intrusion scenarios exist, but several seemed to emerge regularly during the development of the Practical Guideline. Because these recurrences evolved around the same types of sites, the guideline developers determined that walking a



reader through these common scenarios might assist in the decision-making process for a vapor intrusion investigation. The scenarios are based on the assumption that these sites require further investigation as indicated by a preliminary assessment. All emergency (acute) exposures, nuisance conditions, and preliminary screening have been completed, and the site has not exited from the vapor intrusion assessment process. This supplement describes approaches for evaluating the vapor intrusion pathway in six typical scenarios: (1) a gas station in a residential neighborhood, (2) a dry cleaner in a strip mall adjacent to a neighborhood, (3) a large industrial facility with a long plume under several hundred buildings, (4) a vacant lot with proposed brownfield development over a ground-water plume, (5) a vacant large commercial building with warehouse space and office space, and (6) an apartment building with parking garage over a ground-water plume. The purpose of each of the scenarios is to highlight the decision-making process and the reasoning behind the decision, the selection of a specific tool vs. an alternative investigative strategy, and application of the tool in the hypothetical scenario.

<http://www.itrcweb.org/Documents/VI-1A.pdf>

#### Vapor Pressure Characterization to Predict Contaminant Releases from MGP Site Source Area Soils

Hayes, T.D. (Gas Technology Inst., Des Plaines, IL); B.K. Soni (Chr. Hansen, Milwaukee, WI). Soil and Sediment Contamination, Vol 15 No 5, p 511-527, Sep/Oct 2006

The potential of using vapor pressure measurements was assessed as a rapid indicator of the mass-release potential of contaminated soils. The authors focused on determining the relationship between partial pressure and mobility for monoaromatic and polycyclic aromatic hydrocarbon contaminants in source area soils. The investigators found that for a wide spectrum of non-ionized, aromatic contaminants in manufactured gas plant (MGP) soils, total vapor pressure and benzene partial pressure could be measured with good repeatability. Photoionization detector measurements on 16 soil samples from two MGP sites correlated well under controlled conditions to laboratory measurements of equilibrium partitioning and resin-mediated soil contaminant desorption. Vapor pressure was found to correlate well to contaminant mobility in soils.

#### Virtual Chemical Sensors Using a GC/SAW Sensor System

Staples, E.J., Electronic Sensor Technology, Newbury Park, CA); S. Viswanathan (National Univ., La Jolla, CA).

208th ECS Meeting, 16-21 October 2005, Los Angeles, California. Abstract #1280, 2005

Uncoated surface acoustic wave (SAW) resonators were evaluated for the rapid measurement of a mass of eluted chemical compounds from resistively heated ultrafast GC columns. Closed-loop temperature programming of a resistively heated one-meter capillary column at rates as high as 20 degrees C/second produced near real-time, 5-second chromatograms with chemical spectra peak widths measured in milliseconds. Eluted chemicals were physically absorbed on an uncoated SAW resonator, and frequency deviation versus time produced an eluted mass-versus-time chromatogram. The derivative of frequency versus time produces a mass/unit time chromatogram of column flux, which is used to measure the retention times of eluted compounds. An instrument-independent database of chemical spectra can be produced by indexing the retention time of specific target chemicals to the retention times of n-alkane standards. Repeated high-speed chromatographic measurements enable virtual sensor

readings to be updated in near-real time. An array is described of specific virtual chemical sensors for benzene, toluene, ethyl benzene, xylene, trichloroethene, and tetrachloroethene that can be updated every 8 seconds.

Year One Soil Vapor Intrusion Research Study at Stafford Township and Egg Harbor Sites, New Jersey

Golder Associates, Inc., Cherry Hill, NJ.

New Jersey Department of Environmental Protection (NJDEP), Trenton, NJ. 265 pp, Mar 2005

A research program was conducted to evaluate soil vapor intrusion into buildings through field measurements, comparison to existing guidance, and site-specific mathematical modeling of vapor intrusion. An important objective of this study was to obtain supporting information that would assist NJDEP in developing guidance on soil vapor intrusion relevant to conditions in New Jersey. As part of Year One, field monitoring programs were completed at two sites in New Jersey: the Stafford Township site (petroleum hydrocarbons) and the Egg Harbor site in Atlantic County (chlorinated solvents). This report provides a comprehensive description of the field testing programs conducted at the Stafford and Egg Harbor sites, and presents information previously documented in three separate reports. The buildings investigated in the studies consisted of a mixture of small commercial and residential structures, with several types of foundations, including basements. Evaluations were made using field measurements, comparison to existing guidance, and site-specific mathematical modeling of vapor intrusion. This report provides a comprehensive description of the field testing programs conducted at both sites between 2002 and 2004, and presents information previously documented in three separate reports. Important objectives of this study were to develop and refine methods for investigation of soil vapor intrusion into buildings and to obtain supporting information that would assist NJDEP in developing guidance on soil vapor intrusion relevant to conditions in New Jersey.

<http://www.state.nj.us/dep/dsr/air/yr1vapor-intrusion.pdf>

## **SMALL BUSINESS INNOVATIVE RESEARCH (SBIR) AND OTHER GRANT AWARDS**

### **Department of Defense**

Explosives Detection in Residential Building Ventilation Systems (DoD DARPA 2006 SBIR Phase 1)

Jane Bertone, PI, 781-769-9450

EIC Laboratories, Inc., Norwood, MA.

One approach to locating illicit bomb factories in Iraq and Afghanistan is analytical monitoring within the ventilation systems of suspect residential buildings. A multiple sensor analyzer is proposed that sequentially interrogates individual vents or ducts in such buildings and produces fingerprints characteristic of present target substances. The basic premise of this proposal is to locate sensor probes in key ducts or vents and connect them with fiber cabling to a spectral analyzer located in the attic or roof of the building. This setup would monitor different locations within the building with emission of a wireless alarm report to a regional Tactical

Operations Center from all online sensors every 10 to 15 minutes. Reproducible and selective detection of explosives can be achieved using novel self-assembled structures that create an inherently uniform pattern, leading to rapid, reproducible manufacturing. The specific instrument proposed for analyzing the sensors is a field portable spectrograph, with accompanying fiber optic probes, coupled to an accessory containing the sensing elements. Phase I work will focus on the demonstration of reproducible detection of airborne explosives using the sensors in the presence of potentially confusing interfering substances. The Phase II program will focus on quantifying the extent of fouling of the sensors due to long-term exposure to building air, developing a fieldable self-contained and powered instrument including multiplexed probes and wireless communication, and testing the sensors in mock ventilation systems. [DARPA topic 06-022]

Inexpensive TSP Based Reagentless Explosive Detector (DoD DARPA 2006 SBIR Phase 1)  
Anjal Sharma, PI, 979-693-0017  
Lynntech, Inc., College Station, TX.

It is necessary to counter the escalating threat of improvised explosive device attacks on armed forces personnel deployed in foreign locations by seeking out and neutralizing local terrorist operated bomb-making factories. Such factories are typically located in apartment buildings or other large dwellings, where the level of out-gassed explosive marker vapors is so small and buried within numerous common chemicals that current detectors cannot be used to aid in their location. Lynntech proposes to address this critical DoD need by fabricating three novel TSP-based colorimetric sensor elements, each selective for DNT, TNB and picrate, and incorporating them into an automated bench-scale detector to demonstrate the capability to detect and quantify trace vapor phase explosives markers reagentlessly in the presence of common household chemicals and matches. During Phase II, additional selective TSP sensor elements will be fabricated for other molecular explosives markers encompassing groups A through D and integrated these into a prototype, compact, inexpensive explosives-detection device potentially for placement in the HVAC system of apartment buildings. The device will be tested for reliable operation with low false positives, multiplexability, and wireless control during Phase II. [DARPA topic 06-022]

Low Cost Distributed Explosive Detection Device (DoD DARPA 2006 SBIR Phase 1)  
Joseph Birmingham, PI, 360-694-3704  
Microstructure Technologies, Inc., Vancouver, WA.

Automated vapor sampling detectors potentially could provide a detection capability for high vapor pressure explosives such as nitroglycerine (NG); however, for materials such as HMX and RDX, the equilibrium vapor pressures are at least four orders of magnitude lower than conventional trinitrotoluene (TNT) explosives, making detection based on sampling of airborne vapor difficult for all of the explosives without concentration. MicroStructure Technologies has undertaken a mission to develop small, compact, microstructured array detectors for explosive vapors, both nitrogen- and peroxide-based materials. The upstream micropillars on the microstructured array have a high surface area on which the vapors are adsorbed. The laser energy is coupled by fiber optic into the microarray to desorb a concentrated pulse of concentrated explosive vapor. A Microstructured Array Sampler (MAS) with an inorganic

polymer coating is a sensing element to detect the concentrated vapors. The use of the inorganic polymers for explosive detection on an air-sampling microarray for confirmation is innovative. The key innovation of the proposed approach is to use a chip-based laser to selectively desorb a concentrated energetic sample onto sensing polymers coated onto a microarray. An alarm signal from the microarray is sent wirelessly to reveal the type of explosive detected. [DARPA topic 06-022]

### **National Science Foundation**

CAREER: Chemosensors for Neurotoxic Metals (NSF 2005 Continuing Grant)

Award Number: 0548245

January 15, 2006 to December 31, 2007

Awarded Amount to Date: \$340,000

Christopher Chang (PI) [chrischang@berkeley.edu](mailto:chrischang@berkeley.edu)

University of California-Berkeley 510/642-6000

The overall research goal of the program is to develop selective and sensitive chemosensors for neurotoxic heavy metals, with particular interest in detecting mercury and lead for biological and environmental applications. These fundamental studies will aid in the design of practical devices for rapid, on-line screening of toxic heavy metals in various samples, including food, drinking and waste water, and blood and tissue. The application of these chemical tools will also provide insight into molecular targets and mechanisms of heavy metal toxicity and the future design of therapeutics to treat their accumulation.

CAREER: Ultra Low-Power Embedded Sensors for High-Density Remote Monitoring of Water Quality (NSF 2006 Standard Grant)

Award Number 0644511

May 1, 2007 to April 30, 2012

Awarded Amount to Date: \$400,000

Cindy Harnett (PI) [cindy.harnett@louisville.edu](mailto:cindy.harnett@louisville.edu)

University of Louisville Research Foundation Inc., Louisville, KY 502/852-8367

In this five-year proposed CAREER project, newly developed ultra low-power chemical and turbidity sensors will work alongside low-power commercially-available temperature, pressure and flow sensors to provide high-density remote sampling of the watershed environment in eastern Kentucky. The scientific goal of this project is to build and use a low-cost sensor platform for real-time water quality monitoring. Original research will be conducted into ultra low-power chemical and turbidity sensors. These micro- and nanofabricated components will be integrated into a macroscale sensor network using off-the-shelf wireless networking hardware and open-source software that has recently become available. Wireless communication nodes will each connect to dozens of low-power submersible sensors at different depths; since depths and sensor types depend on the application, a standard electrical and mechanical sensor interface will allow users to easily customize the network. The end result will be a new set of low-cost research tools available to help environmental and geological researchers ask new scientific questions, backed by the ability to carry out watershed monitoring projects with greater data resolution than ever before. Mining, agriculture, and natural events contribute to both

degradation of water quality and changes in the hydrological dynamics of ground and surface water flow, yet the impracticality of accessing a remote streambed during a storm, and the low spatial density of conventional sampling, have made it difficult to pinpoint the source of a change in water quality without after-the-fact laboratory techniques. The broader impact of these remote access real-time water quality maps will be an improved ability to monitor, understand, and mitigate sources of pollution affecting human and ecological communities.

Chemical Sensors Based upon Electrodeposited Metal Nanowires (NSF 2006 Continuing Grant)

Award Number: 0641169

February 15, 2007 to January 31, 2008

Awarded Amount to Date: \$205,219

Reginald Penner (PI) [rmpenner@uci.edu](mailto:rmpenner@uci.edu)

University of California-Irvine 949/824-4768

The Analytical and Surface Chemistry (ASC) program of the Division of Chemistry will support the research program of Prof. Reginald Penner of the University of California at Irvine. Prof. Penner and his students will investigate the mechanism responsible for metal nanowire-based molecular detection. The goal of the study is to test for the existence of Chemically Responsive Interparticle Boundaries (CRIBs: metal oxide layers located at grain boundaries within polycrystalline nanowires), map their location within nanowires, and understand their function. Success of the project would lead to the development of new and improved nanowire sensors that could be used in many applications related to diagnostic medicine, defense and homeland security.

Collaborative Research: Characterization of Fractured Rock Aquifers Using Hydromechanical Well Tests (NSF 2006 Continuing Grant)

Award Number: 0609950

August 1, 2006 to July 31, 2007

Awarded Amount to Date: \$50,000

Leonid Germanovich (PI) [leonid@ce.gatech.edu](mailto:leonid@ce.gatech.edu)

GA Tech Research Corporation -- GA Institute of Technology, Atlanta 404/385-0866

An important fraction of the world's supply of hydrocarbons and fresh groundwater occurs in geologic formations with fractures cutting through a tight matrix. It is understandable that considerable effort has been put into efforts to understand how these fluids are stored and transmitted through the pore spaces along fractures. Although commonly viewed as rigid conduits, fractures in rock are actually somewhat compliant, gapping open in response to even modest increases in pressure and shrinking closed when pressure drops. Measuring and interpreting both displacement and pressure while pumping is the essence of a hydromechanical well test. Measurements of both pressure and displacement can be used to determine the storativity of an aquifer using data from a pumping well alone; conventional methods require using an observation well to estimate storativity. The purpose of this project is to develop and refine field techniques for conducting and analyzing hydromechanical well tests. The project is motivated by efforts to address aquifer characterization, well performance, joint formation, and Earth tides. The intellectual merit of the proposed project includes advances in three primary arenas: a) theoretical analyses of fracture hydromechanics, b) field techniques and

instrumentation, c) field applications and hypothesis testing at sites underlain by fractured rock aquifers. The project will produce innovations in portable extensometers that can be used during well tests, and new theoretical analyses will be developed for predicting and inverting displacement and pressure signals obtained during hydromechanical well tests. It is possible to invert an axisymmetric model of coupled fluid flow and deformation in fractures to estimate heterogeneities at some distance from the pumping well. Hydromechanical well tests offer promise, both as a technique that stands alone and as one that is integrated with other methods in the characterization of fracture rock aquifers. This project will provide insights that cut across fields related to groundwater production and remediation, geothermal energy, oil and gas production, disposal of hazardous wastes by deep well injection, disposal of nuclear wastes in repositories, earthquake and tsunami prediction, landslide mechanics, rock mechanics, and a variety of other disciplines concerned with fluid flow and deformation in fractured rock. The project will initiate an innovative educational partnership between Clemson and Georgia Tech.

Collaborative Research: Characterization of Fractured Rock Aquifers Using Hydromechanical Well Tests (NSF 2006 Continuing Grant)

Award Number: 0609960

August 1, 2006 to July 31, 2007

Awarded Amount to Date: \$110,000

Lawrence Murdoch (PI) [lmurdoch@clemson.edu](mailto:lmurdoch@clemson.edu)

Clemson University, Clemson, SC 864/656-2424

An important fraction of the world's supply of hydrocarbons and fresh groundwater occurs in geologic formations with fractures cutting through a tight matrix. It is understandable that considerable effort has been put into efforts to understand how these fluids are stored and transmitted through the pore spaces along fractures. Although commonly viewed as rigid conduits, fractures in rock are actually somewhat compliant, gapping open in response to even modest increases in pressure and shrinking closed when pressure drops. Measuring and interpreting both displacement and pressure while pumping is the essence of a hydromechanical well test. Measurements of both pressure and displacement can be used to determine the storativity of an aquifer using data from a pumping well alone; conventional methods require using an observation well to estimate storativity. The purpose of this project is to develop and refine field techniques for conducting and analyzing hydromechanical well tests. The project is motivated by efforts to address aquifer characterization, well performance, joint formation, and Earth tides. The intellectual merit of the proposed project includes advances in three primary arenas: a) theoretical analyses of fracture hydromechanics, b) field techniques and instrumentation, c) field applications and hypothesis testing at sites underlain by fractured rock aquifers. The project will produce innovations in portable extensometers that can be used during well tests, and new theoretical analyses will be developed for predicting and inverting displacement and pressure signals obtained during hydromechanical well tests. It is possible to invert an axisymmetric model of coupled fluid flow and deformation in fractures to estimate heterogeneities at some distance from the pumping well. Hydromechanical well tests offer promise, both as a technique that stands alone and as one that is integrated with other methods in the characterization of fracture rock aquifers. This project will provide insights that cut across fields related to groundwater production and remediation, geothermal energy, oil and gas production, disposal of hazardous wastes by deep well injection, disposal of nuclear wastes in

repositories, earthquake and tsunami prediction, landslide mechanics, rock mechanics, and a variety of other disciplines concerned with fluid flow and deformation in fractured rock. The project will initiate an innovative educational partnership between Clemson and Georgia Tech.

#### Continuous Monitoring Of Volatile Organic Compounds During Kiln Drying With The MEMS Chemical Sensors (NSF 2006 STTR Phase 1)

Award Number: 0637787

January 1, 2007 to December 31, 2007

Awarded Amount to Date: \$150,000

Todd Mlsna (PI) [tmlsna@seacoastscience.com](mailto:tmlsna@seacoastscience.com)

Seacoast Science, Inc., Carlsbad, CA 760/268-0083

This Small Business Technology Transfer (STTR) Phase I Project focuses on the development of a monitor for volatile organic compounds released during wood processing. A MEMS detector system that can continuously monitor pollutants during wood processing will be developed. The program proposed here will provide a real-time continuous monitor with an overall significant cost reduction when compared to traditional monitoring methods. Plywood and composite wood products release major sources of hazardous air pollutants during processing, including, acetaldehyde, acrolein, formaldehyde, methanol, phenol, propionaldehyde and others. These pollutants are associated with a variety of adverse health effects, including damage to nasal membranes, gastrointestinal irritation, irritation of eyes, throat, and mucous membranes, dizziness, headache, and nausea. The chemicapacitive sensor technology being developed has a broad relevance in wood processing as well as in other commercial applications. These sensors are ideal for monitoring a variety of chemical and physical targets in a distributed system where a premium is placed on early detection of problems.

#### Electrochemical Detection of Peroxide-Based Explosives (NSF 2007 Standard Grant)

Award Number: 0707038

February 15, 2007 to January 31, 2008

Awarded Amount to Date: \$70,032

I Cheng (PI) [ifcheng@uidaho.edu](mailto:ifcheng@uidaho.edu)

University of Idaho, Moscow, ID 208/885-6689

From an intellectual merit perspective, there is an urgent need for methods and techniques that are able to detect quantitatively and qualitatively peroxide based explosives. The basic chemistries for such endeavor have not been fully described. This investigation will examine the electrochemical mediation of the Fenton Reaction as a basis for detection of this class of explosives. The mediation takes place as a result of the homogeneous Fenton Reaction and the electro-reduction of an FeIII complex to FeII.  $\text{FeII complex} + \text{RO-OR FeIII complex} + \text{RO-} + \text{RO}$ . The current due to the electro-reduction of the FeIII complex is proportional to the square root of the peroxide concentration. The process is expected to be rapid, robust, and inexpensive. The proposed study will examine the detection limits, kinetics, and the role of the chelate of the iron complex. The latter is based on considerations of the structure-activity relationships developed by cyclic voltammetric studies. This Small Grant for Exploratory Research (SGER) seeks to prove that this novel approach to detection of peroxide based explosives can be utilized and will have broader impacts. If successful, the PI anticipates that this SGER proposal will lead to a more detailed EXP proposal where the Fenton's Reagent-based

system will be further explored and characterized within a carefully crafted experimental and teaching plan. The PI may seek further funding for these concepts from other government agencies, as well as other NSF program elements.

Forensic Analysis of a Final Cover Relying on a Clay Barrier (NSF 2004 SGER Grant)

Award Number 0437306

July 15, 2004 to June 30, 2005

Awarded Amount to Date: \$28,000

Craig Benson (PI) [benson@engr.wisc.edu](mailto:benson@engr.wisc.edu)

Univ. of Wisconsin-Madison 608-262-3822

Final covers that rely on a compacted clay barrier generally consist of a layer of compacted clay 450-900 mm thick overlain by an erosion layer that is 150 mm to 900 mm thick. The saturated hydraulic conductivity of the clay generally is required to be less than 10(-7) cm/s, which corresponds to a maximum percolation rate of 32 mm/yr under conditions of continuous gravity drainage. Thousands of these covers have been constructed in the U.S.; however, there is growing concern that these covers are unlikely to perform as intended over the long term due to the destructive effects of desiccation and frost action. Field data suggest that these processes are resulting in percolation rates that are much higher than intended (hundreds of mm per yr), but detailed investigations have not yet been conducted to show that the high percolation rates are definitively tied to morphological changes in the clay barrier layer. In the proposed study, a forensic investigation of the cover will be conducted, the result being a unique and novel data set describing the effects of weathering on the fabric, hydrologic properties, and field performance of a clay barrier in a cover. A series of field and laboratory tests will be conducted. Field hydraulic conductivity tests that permeate different volumes of soil will be conducted directly on the barrier layer and large undisturbed samples of the barrier layer will be retrieved for laboratory hydraulic conductivity testing. The pathways conducting flow will be marked with dye added to the permeant water used for the hydraulic conductivity tests. After permeation, transects will be excavated in the cover to study the aperture, length, and spacing of the dye-stained cracks. A similar examination will be conducted after permeating the laboratory specimens. The study has economic, environmental, and societal impacts. Economic and environmental impacts will be realized by providing a thorough evaluation of the effectiveness of the most common remedy used in Superfund projects. The results of this study may show that other cover technologies are likely to be more cost effective and environmentally protective over the long-term than covers relying on a compacted clay barrier.

A Green Fieldable Analyzer for Arsenic (NSF 2004 Standard Grant)

Award Number: 0456120

February 15, 2005 to December 31, 2006

Awarded Amount to Date: \$353,000

Purnendu Dasgupta (PI) [Dasgupta@uta.edu](mailto:Dasgupta@uta.edu)

Texas Tech University, Lubbock, TX 806/742-3884

Most fieldable arsenic detectors involve the use of the toxic chemicals lead and mercury. Further, most test kits are not suitable for analyzing arsenic below 10 microgram/L (the current acceptable level set by WHO), and the method developed in this work will improve this sensitivity. The instrument is based on sequential injection (for speciation), zone fluidics (for hydride generation), and gas phase chemiluminescence (for detection). The integrated arsenic



analyzer includes concentration and separation of arsenic species with ion exchange cartridges, electrooxidation of As(III) to As(V), electroreduction of As(V) to arsine with an electrolytic arsine generator, membrane-based electrodialytic salt splitter, and enhanced ozone generation by electrical discharge and oxygen feed. It only requires the use of NaCl and electricity to enable analysis of arsenic at the sub-microgram/L levels. With a preliminary setup, the PI achieved detection limits of around 0.1 ppb using only a 2 mL sample. By adjusting acidity, he can distinguish between arsenic(III) and arsenic(V), and he can detect organic arsenic species.

A Green Fieldable Analyzer for Arsenic (NSF 2007 Standard Grant)

Award Number: 0709994

December 1, 2006 to January 31, 2009

Awarded Amount to Date: \$272,223

Purnendu Dasgupta (PI) Dasgupta@uta.edu

University of Texas at Arlington 817/272-2105

Most fieldable arsenic detectors involve the use of the toxic chemicals lead and mercury. Further, most test kits are not suitable for analyzing arsenic below 10 microgram/L (the current acceptable level set by WHO), and the method developed in this work will improve this sensitivity. The instrument is based on sequential injection (for speciation), zone fluidics (for hydride generation), and gas phase chemiluminescence (for detection). The integrated arsenic analyzer includes concentration and separation of arsenic species with ion exchange cartridges, electrooxidation of As(III) to As(V), electroreduction of As(V) to arsine with an electrolytic arsine generator, membrane-based electrodialytic salt splitter, and enhanced ozone generation by electrical discharge and oxygen feed. It only requires the use of NaCl and electricity to enable analysis of arsenic at the sub-microgram/L levels. With a preliminary setup, the PI achieved detection limits of around 0.1 ppb using only a 2 mL sample. By adjusting acidity, he can distinguish between arsenic(III) and arsenic(V), and he can detect organic arsenic species. The method being developed here would be applicable to field work, even in rural areas of India and Bangladesh devastated by arsenic poisoning.

Integrated Field Asymmetric Ion Mobility Sensor for Volatile Organic Compound Detection (NSF 2006 SBIR Phase 1)

Award Number: 0637609

January 1, 2007 to June 30, 2007

Awarded Amount to Date: \$99,038

Andrew Koehl (PI) andrew.koehl@owlstonenanotech.com

Owlstone Nanotech, Inc., New York, NY 212/583-0098

This Small Business Innovation Research (SBIR) Phase I project will demonstrate the feasibility of a novel micro-fabricated gas sensor for detection of airborne volatile organic compounds (VOCs) at concentrations below 1 part-per-million. The key enabling innovation is the combination of field asymmetric ion mobility spectrometry (FAIMS) with corona discharge ionization (CDI), with both functions integrated on to a single sensor chip. This integration and the use of batch micro-fabrication techniques will deliver the high sensitivity and selectivity of ion mobility chemical detection in a small, low-cost sensor suitable for air quality monitoring and early warning fire detection. The broader impact of this will be to pave the way for prototyping and testing of a highly sensitive and selective CDI-FAIMS sensor suitable for VOC

monitoring in a range of consumer and industrial applications. The adverse health effects of a range of VOCs are well-known, but effective mass-market technologies for monitoring them in domestic and work environments do not yet exist. Commercialization of a small, sensitive, low cost VOC sensor could therefore have an enormous positive impact on human health and safety.

Joint Stochastic Non-Linear Inversion of Hydrogeophysical Data for Improved Vadose Zone Characterization and Monitoring (NSF 2004 Continuing Grant)

Award Number: 0439649

January 15, 2005 to December 31, 2007

Awarded Amount to Date: \$270,000

Yoram Rubin (PI) rubin@ce.berkeley.edu

University of California-Berkeley 510/642-6000

A characterization approach that can handle the nonlinearities and complexities inherent in vadose zone flow, including hysteresis and preferential flow, and geophysical processes, is still a challenge. The objective of the proposed research is to develop a stochastic inversion procedure. We shall focus on the combined use of crosshole radar (GPR) and hydrogeologic data such as soil moisture and pressure head, obtained from boreholes, to provide high-resolution imaging of soil moisture dynamics, and subsequently for inverse modeling. Our hypothesis is that an inversion framework that is based on simultaneous inversion of geophysical and hydrological measurements and on non-linear modeling of the flow processes and of the geophysical surveys, improves our ability to characterize the vadose zone. The inversion of the geophysical and hydrogeological data will be carried out simultaneously using non-linear mathematical models of the flow and geophysical processes to relate between target parameters (lithology, permeability, other soil parameters needed for modeling of the relative conductivity and water retentivity), and input data. Current methods for integrating hydrogeological and geophysical data are either sequential or iterative. The problem with sequential methods is that the error associated with the geophysical inversion is ignored, and the problem with the iterative methods is that convergence is not guaranteed, unless special conditions are met, which are difficult to evaluate. Several promising inversion procedures have been explored recently based on linearization (low-order approximations in terms of variability) of the flow equation. Our fully non-linear approach will explore their strength and limitations. The procedure will be stochastic in nature, with the goal of characterizing the target parameters through their multivariate spatial probability distributions. The proposed approach will be tested using a digital analog-based synthetic model and data from a field experiment carried out at the DOE site at Hanford. The synthetic study will test our ability to identify the soil's hydraulic parameters away from wells, and the Hanford study will assess our capability to improve predictive capabilities.

Low-Cost RFID Dioxin Sensors (NSF 2005 SBIR Phase 1)

Award Number: 0539630

January 1, 2006 to December 31, 2006

Awarded Amount to Date: \$100,000

Brian Elliott (PI) bellott@tda.com

TDA Research, Inc., Wheat Ridge, CO 303/940-2301

This Small Business Innovation Research Phase I project will develop a new material that can selectively detect dioxins and to incorporate this sensor material into a radio-frequency identification (RFID) tag to produce low-cost dioxin sensors that can be used to monitor the food supply for unusually high levels of dioxin contamination. The same equipment used for RFID-

based inventory control can then interrogate these RFID sensors. Dioxins are extremely toxic and persistent chemicals that originate from combustion processes and accumulate in the food chain. Increased levels of dioxins in the body are known to cause cancer and other diseases. Despite the significant risk posed by accidental and intentional contamination of food products (especially meat and dairy products) there are no low-cost methods for detecting dioxins. Current testing costs \$600 to \$800 per sample. This project will seek to develop very low-cost sensors that can be incorporated into the packaging for food products. These sensors could also be used to help track the quality of animal feed and prevent dioxin contamination of livestock.

Mass-Sensitive Microsensor Platform for Liquid-Phase Environmental Sensing (NSF 2006 Standard Grant)

Award Number: 0606981

June 15, 2006 to May 31, 2008

Awarded Amount to Date: \$230,000

Oliver Brand (PI) oliver.brand@ece.gatech.edu; Boris Mizaikoff (Co-PI)

GA Tech Research Corporation - GA Institute of Technology, Atlanta 404/385-0866

The project seeks to develop a mass-sensitive chemical sensor platform for detection of volatile organic compounds (VOCs) in water. The technology to be used would employ chemically sensitive enrichment layers which sorb mass selectively and change the resonance frequency of the sensor device. The shape of the resonator is a novel disk shape rather than a cantilever resonator. This innovation is to improve the frequency resolution by employing shear, rather than compression of the surrounding fluid. The proposed sensor has the potential for inclusion in a wide variety of compact chemical and biological sensing systems, and possible implementation as part of a distributed network. The successful development of a system of this kind would potentially have both health and security benefits.

Micro-Fabricated, Multi-Species, Highly Selective Integrated Gas Sensors Based on Absorption and Adsorption (NSF 2006 SBIR Phase 1)

Award Number: 0637617

January 1, 2007 to June 30, 2007

Awarded Amount to Date: \$99,996

Joon-Ho Koh (PI) jkoh@msrihome.com

Materials & Systems Research Inc., Salt Lake City, UT 801/973-1199

This Small Business Innovation Research Phase-I project involves the design and fabrication of highly selective, fast response, miniaturized gas sensors using micro-fabrication techniques wherein the sensing response is related to lattice absorption as well as surface adsorption of a given species in conducting perovskite oxides. For gases such as H<sub>2</sub>O, O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, NO<sub>x</sub>, and SO<sub>x</sub>, which are supplied or produced in power plants, selectivity of gas sensors is required. The currently used adsorption-based gas sensors suffer from significant interference effects from co-existing species, thereby reducing their selectivity for a given species of interest. This concept of a new sensor design will be investigated for many other industrially and environmentally important gaseous species by pairing them with proper sensing materials based on perovskite oxides. The broader impact of the work is to bring highly selective micro-sensors into application for accurate monitoring on gases used or produced in power plants or other

industrial plants so that the online control of those gas species can be more effective and the overall process efficiency can be dramatically increased.

NER: Nanowire Spectrophotometer for Lab-on-a-Chip Chemical Analysis (NSF 2006 Standard Grant)

Award Number: 0609083

July 15, 2006 to June 30, 2007

Awarded Amount to Date: \$108,470

Ritesh Agarwal (PI) riteshag@seas.upenn.edu; David Gracias (Co-PI)

University of Pennsylvania, Philadelphia 215/898-7293

This project will develop a new type of nano-scale device called a nanowire spectrometer for chemical analysis. The work will involve four steps: (1) synthesis and characterization of CdS, CdSe, and ZnS nanowires with energy band gaps in the UV-Visible region; (2) fluidic assembly of single nanowires and 2-D nanowire rafts onto insulator substrates; (3) fabrication and optical testing of self-aligned gaps within nanowires and nanowire rafts; and (4) fabrication of spectrometers (single and multiple wavelength) by integrating the nanowire light source and detector with microfluidics. The broader impacts of the project include closely coupled research and education plans. Successful completion of the project could lead the development of low-cost, portable, miniature optical spectrometers with potential applications in environmental monitoring, biomedicine, and other fields.

NER: Polymer Nanowire Chemical Sensors for Aqueous Media (NSF 2005 Standard Grant)

Award Number: 0507921

July 15, 2005 to June 30, 2007

Awarded Amount to Date: \$130,000

D. Eric Aston (PI) aston@uidaho.edu

University of Idaho, Moscow, ID 208/885-6689

This project is assessing the feasibility of using nano-wires made of non-conductive polymers to detect various ions in solution. The hypothesis is that resistivity of such polymer wires are affected by sorption of electrolytes from the water and that ions with different mobilities would alter the electrical conductivity of the polymer in different ways. The work involves three objectives: fabrication of aqueous nanowire sensors, electrical characterization of the nanowires, and development of nanowire electrical contacts and dual sensors based on nanowire concepts. The study will evaluate whether polymer-based nanowires are more versatile than modified metal or ceramic nanowires and more affordable to manufacture. Understanding the behavior of polymer nanowires could lead to the development of many kinds of novel sensors and control options.

Novel Wafer Fabrication Technology for Semiconductor Sensors (NSF 2005 SBIR Phase 2)

Award Number: 0522039

September 1, 2005 to August 31, 2007

Awarded Amount to Date: \$471,833

Rabi Bhattacharya (PI) rbhattacharya@ues.com

UES, Inc., Dayton, OH 937/426-6900

This Small Business Innovation Research (SBIR) Phase II project is directed toward the development of cadmium zinc telluride (CdZnTe) single crystal films by using an ion beam layer

separation process from bulk single crystals. The separated layers will be transferred and bonded on to silicon (Si) wafers for applications as substrates for epitaxial growth of mercury cadmium telluride (HgCdTe) films. HgCdTe films are of interest in infrared detectors. The ion beam layer separation process will allow the fabrication of a large number of films from a single bulk crystal, thus providing an economical wafer production technology for infrared detector materials. High-energy (MeV) light ions will be used to produce a buried damaged layer in the bulk crystal. Thermal annealing at elevated temperatures may generate lateral crack enabling the layer separation. Phase I has shown the feasibility of this approach. Phase II research objectives are to optimize the process parameters for wafer-scale separation without breaking and develop the process to transfer the separated films on to Si wafers. The wafers thus fabricated will be used for epitaxial growth of HgCdTe and fabrication of IR detectors. CdTe and (CdZnTe) alloy crystals have been grown by various techniques including zone refining, vertical gradient freeze (VGF), liquid encapsulated Czochralski (LEC) methods, horizontal and vertical Bridgman techniques. Due to variable yields, none of these methods have produced enough material with the quality needed for today's infrared (IR) detector applications. The proposed method has been developed to overcome these limitations. Commercially, the proposed technique has the advantage of producing many good quality substrates from a single bulk crystal by ion beam slicing, thus providing an economic way of producing reliable and reproducible quality material. Also, large area CdZnTe substrate for the growth of HgCdTe will be possible by stacking smaller slices in a floor tile pattern on cheaper Si substrates. Bonding with Si substrate will also allow the integration of IR detectors with electronics on a single chip. IR photodetectors and focal plane arrays are of interest in many industrial and scientific applications including environmental monitoring, chem-bio detection, medical and space sensors.

A Perchlorate Bioassay (NSF 2006 SBIR Phase 1)

Award Number: 0611179

July 1, 2006 to April 30, 2007

Awarded Amount to Date: \$100,000

Susan O'Connor (PI) soconnor@bioinsite.com; Kelly Bender (Former PI)

BioInsite, LLC, Carbondale, IL 618/549-6868

This Small Business Innovation Research Phase I project aims to develop a sensitive and cost effective colorimetric bioassay for perchlorate determination in environmental samples. Perchlorate is known to affect thyroid hormone production potentially leading to neuropsychological development deficiencies. The technique proposed will take advantage of the reported ability of the nitrate reductase enzyme to reduce perchlorate to chlorite and a highly sensitive colorimetric assay for the quantitative measurement of low-level chlorite concentrations. The chlorite assay is based upon the enzymatic reaction between chlorite and horseradish peroxidase resulting in the quantitative production of chlorine dioxide which further chemically reacts with o-dianisidine to yield a yellow color. Once a nitrate reductase has been optimized for perchlorate reduction, feasibility of the technique will be dependent on the sensitivity and accuracy of the bioassay when applied to environmental samples. This proposed bioassay will create a simpler, more efficient, and cost effective method to detect low levels of perchlorate in environmental samples. Adaptation to a dipstick type test will also aid in field site analysis and provide a commercial diagnostic kit. With over 90 known perchlorate releases throughout 35 US states, this technology will benefit businesses, environmental service firms,

site owners, and federal, state, and local government entities in their efforts to protect and remediate water supplies.

Plant Bioreporters for Arsenic (NSF 2005 STTR Phase 2)

Award Number: 0548751

October 1, 2006 to September 30, 2008

Awarded Amount to Date: \$500,000

Mark Elless (PI) [elless@edenspace.com](mailto:elless@edenspace.com)

Edenspace Systems Corp., Chantilly, VA 703/961-8700

This Small Business Technology Transfer Research (STTR) Phase II project will develop plant bioreporters for arsenic which is widely dispersed in the environment. Detecting and monitoring arsenic in soil and water, particularly in large or remote areas, is often cost-prohibitive due to the expense of sample collection and analysis. This research will lead to an innovative, cost-effective, real-time system to monitor water and soil quality offering high spatial resolution, stand-off reporting, ready scaling to large treatment areas, and continuous in place reporting of bioavailable arsenic. Applications for this technology include detection and investigation of arsenic contamination and risk assessment during remedial activities at contaminated sites. The broader impact of this technology will be to enable more extensive use of in place environmental cleanup methods such as phytoremediation, assist efforts to monitor and clean the environment, and reduce environmental health hazards posed by arsenic. Improving the ability to accurately assess arsenic contamination will improve awareness of contaminated areas and make affordable arsenic monitoring by homeowners, farmers, and industry. Of particular usefulness would be the ability of farmers and gardeners to detect the potential bioavailability of arsenic to food crops as a result of arsenic in biosolids and pesticides.

Quantifying Gene Expression to Predict and Optimize Reductive Dechlorination by *Dehalococcioides* spp. (NSF 2005 Continuing Grant)

Award Number: 0504244

May 1, 2005 to April 30, 2008

Awarded Amount to Date: \$536,257

Lisa Alvarez-Cohen (PI) [alvarez@ce.berkeley.edu](mailto:alvarez@ce.berkeley.edu)

University of California-Berkeley 510/642-6000

The proposed work would provide more insight into the role of multiple *Dehalococcioides* strains in dechlorination of chlorinated solvents by comparing measured 16S and expressed genes for known reductases. There would also be potential discovery of novel reductases. The plan also calls for study of a range of community structure from pure cultures of strain 195 to combinations of known cultures to well characterized mixed cultures to mixed cultures that have had relatively little characterization. These could reveal identities of synergistic species important to the ecology of *Dehalococcioides* populations; however, the latter result is probably the least likely.

Sampling and Inversion Methods for Quantifying Effect of Incomplete Subsurface Characterization on Uncertainty Associated with Recovery of Contamination History (NSF 2006 Standard Grant)

Award Number: 0607002

September 1, 2006 to August 31, 2008

Awarded Amount to Date: \$185,881

Anna Michalak (PI) anna.michalak@umich.edu

University of Michigan, Ann Arbor 734/764-1817

This project will employ inverse modeling to trace contaminants in groundwater to the source of the contamination. Three methods will be developed to incorporate uncertainties in transport parameters into the modeling: Monte Carlo simulation, small perturbation approximation, and co-kriging. Results of these three methods will be tested with field data and hypothetical applications at Dover Air Force Base, Delaware, and Gloucester Landfill, Canada. The results of this research also will be used to develop guidelines to determine the extent to which the history of contamination can be quantified given uncertainties associated with transport parameters. Development of capabilities to trace contaminants to their source will contribute to the identification of responsible parties and could lead to improved practices that correct such problems.

Sensing, Analyzing, and Forecasting Evaluation (SAFE) System for Bioreactor Landfills (NSF 2005 Continuing Grant)

Award Number: 0510091

September 15, 2005 to August 31, 2007

Awarded Amount to Date: \$153,079

Milind Khire (PI) khire@egr.msu.edu

Michigan State University, East Lansing 517/355-1855

During the past two decades, the majority of geotechnical and geoenvironmental research related to landfills using in situ sensing systems and field methods has been focused on securing the boundaries of the landfills -- caps and liners. This research concerns sensing the "heart" of landfills, which is the waste representing over 99% of the landfill. The proposed approach will use the data collected from sensors embedded in permeable blankets primarily used for routine leachate recirculation to continuously and in real-time model the changes in the hydraulic and thermal conductivities of waste. This is critical because hydraulic and thermal properties of the waste change as a result of settlement, decomposition, age, and other operational variables. Currently, we have only limited knowledge on the long-term behavior and risks associated with "megafills" operated as bioreactors. In addition, the proposed approach will be independently confirmed by doing controlled lab experiments using a lab-scale physical model of a landfill followed by comprehensive numerical modeling and by conducting field tracer tests at an instrumented landfill site in Michigan. The research activities combine the use of well-established in-situ sensor technology to measure water content, liquid pressure, temperature, vertical stress, and settlement and sophisticated computer models in a unique manner to develop a knowledge base and preliminary framework for SAFE system capable of sensing, analyzing, and potentially forecasting landfill-specific behavior to optimize the performance of landfills and reduce environmental risks. Such sensor systems can be readily and consistently implemented at any landfill. This would herald the next era of landfill design, shifting the focus from boundaries

to an overall landfill-specific approach. In parallel to the research activities, design of liquid injection systems for landfills will be interwoven with undergraduate research and course development. An easy to use labscale physical model of a landfill will be designed and built to make it possible for students to observe, investigate, control, and interact with the hydraulics of liquid collection and injection systems in ways not previously possible. The relatively compact landfill demonstration model will provide an innovative educational tool for teaching landfill design or equivalent courses at Michigan State and other universities. This project will allow collaboration with landfill regulators and operators and will allow undergraduate students to participate in an existing NSF-funded international project, providing a unique research opportunity. It would also provide new learning directions for minorities and female students via local high school programs serving these groups that are actively tied to Michigan State University. The economic impacts of the proposed research will accrue with our ability to potentially reduce long-term risks and financial liabilities associated with over 2,000 ubiquitous active landfills in the U.S. and as recycled materials find an additional market.

SGER: Deployment of Wireless Sensor Network for Analysis of Irrigation Effects on Subsurface Redox Conditions and Arsenic Mobilization in Bangladeshi Aquifer (NSF 2006 Standard Grant)

Award Number: 0605515

May 15, 2006 to April 30, 2007

Awarded Amount to Date: \$28,698

Jennifer Jay (PI) [jjay@seas.ucla.edu](mailto:jjay@seas.ucla.edu); Charles Harvey (Co-PI)

University of California-Los Angeles 310/794-0102

This award supports travel and field expenses for the PI and colleagues, including two graduate students, to conduct research in Bangladesh as part of a multi-university and interdisciplinary team investigating the factors causing toxic concentrations of arsenic in shallow ground water of the Ganges Delta. High concentrations of arsenic in ground water constitute a major public health problem in Bangladesh, as tens of millions of people rely on contaminated ground water supplies for drinking water. Numerous cases of arsenicosis and arsenic-induced skin cancer have been reported, and this is regarded as one of the largest environmental poisonings in history. Specific goals of the project are to (i) deploy a wireless sensor network to test three hypotheses regarding mobilization of arsenic in shallow aquifers under rice paddies; (ii) field test a new software tool designed to aid in debugging run-time problems in sensor networks; and (iii) use the collected data to develop a reactive-transport model of subsurface redox conditions and how they are affected by irrigation. The proposed work is aimed at improving scientific understanding of the factors giving rise to arsenic mobilization in ground-water aquifers, a topic of considerable interest in environmental science and practical concern for management of this widespread problem. Previous studies have established that redox conditions play an important role in arsenic mobilization, but the nature of that role and how irrigation affects this remain unclear. The work also is aimed at advancing our experience with sensor networks in environmental systems and dealing with problems that arise in deploying sensitive sensors under harsh conditions. This experience will be useful relative to deployment of sensor networks for environmental observatories in the U.S. In addition, the study should improve general understanding of arsenic mobilization in aquifers that applies beyond Bangladesh; arsenic contamination of ground water also is a common problem in the U.S. This award is funded jointly by the Environmental Engineering Program and OISE.



SGER: Functional Optical Probes for In-Situ Monitoring of the Geo-Environmental (NSF 2006 Standard Grant)

Award Number: 0627312

September 1, 2006 to February 28, 2007

Awarded Amount to Date: \$39,870

Konstantinos Kostarelos (PI) dino@poly.edu; Masoud Ghandehari (Co-PI)

Polytechnic University of New York, Brooklyn 718/260-3550

This proposal seeks funding to develop "design and synthesis" poro-selective membranes for application as coatings to optical fibers. Using such specialty cladding materials, the light radiating within the fiber will interact with the outside environment and transduce the presence and concentration of target species (chlorinated hydrocarbons, heavy metals, PAHs, etc.). The results of our proposal are the first steps toward our long-term objective: to introduce chemo-optical spectroscopy as a tool for real-time, remote monitoring of transport processes within the subsurface environment. In addition, several other geo-environmental applications that focus on waste containment and site remediation issues can be exploited by the technology being developed under this grant. In telecommunications, optical fibers are produced so that light inside the fiber does not interact with the external environment; however, for chemical sensing, specialty porous cladding materials may be employed to serve as a zone of interaction, where light is modulated by the medium it encounters. The electromagnetic field is termed the evanescent field. Evanescent field spectroscopy has been known to scientists for many years; however, lack of focused activity on the production of effective coating materials has been an obstacle to the commercial availability of waveguide chemical sensor devices.

SGER: Rapid Assessment Techniques in Support of Soil/Sediment Removal Strategies for Katrina Cleanup (NSF 2005 Standard Grant)

Award Number: 0553970

October 15, 2005 to January 31, 2006

Awarded Amount to Date: \$19,700

James Ranville (PI) jranvill@mines.edu; Thomas Wildeman (Co-PI)

Colorado School of Mines, Golden 303/273-3000

Vast quantities of soil and sediment were deposited by Hurricane Katrina within urban areas, such as New Orleans. Does this material contain chemical contaminants at levels of concern? The answer to this question will define how and where the material can be disposed of, what degree of personal protection gear must be worn by workers removing it, and if any further environmental concerns will be posed by this material after removal. There are two questions that must be answered to move forward with soil and sediment removal. (1) Is the material considered hazardous waste and must therefore be disposed of in special landfills? (2) Does the material pose a toxicity risk to humans and/or the environment? Both of these questions must be answered quickly. This urgency poses a challenge to some of the conventional means of addressing these questions, and new assessment approaches are needed. We are proposing to answer each of these two questions through the application and validation of new techniques that we have been developing, generally in the context of mine site evaluations. We will apply to these samples an acidic solution (acetic acid) designed to leach contaminants from the solids

under conditions that simulate a landfill. This field-based test will be developed and calibrated by comparison to standard TCLP tests. The measurements will focus on toxic metals (Pb, As, Cd, Cr, Ni, Cu, Zn, etc.) with an emphasis on lead and arsenic. In this way, we will determine if a need for specialized disposal of these materials exists. The goal here is to make a field-portable method that approximates the results of the slower and more laborious EPA-approved TCLP test.

SST: Chip-based Electrochemical Sensor System for Monitoring Heavy Metals in Water (NSF 2005 Standard Grant)

Award Number: 0529140

September 15, 2005 to August 31, 2008

Awarded Amount to Date: \$300,356

Richard Baldwin (PI) rick.baldwin@louisville.edu; Kevin Walsh (Co-PI); Robert Keynton (Co-PI); John Naber (Co-PI)

University of Louisville Research Foundation Inc., Louisville, KY 502/852-8367

The goal of this project is to build and test a prototype lab-on-a-chip (LOC) electrochemical (EC) sensor for heavy metals to be used in monitoring drinking water. The proposed LOC will be designed to be a robust, portable, stand-alone sensing system for use by municipal water companies to identify and quantify low levels of the heavy metals Pb, Cu, Hg, Ni, and Zn. Such robust, small, sensitive and inexpensive sensors are needed for sensor array applications. The LOC will be coupled with a transportable, battery-powered electronics package suitable for on-site or remote applications that the PIs developed previously. The project involves several innovative components, such as the use of different flow paths for pre-concentration and sensing, use of gold-electrodes, a 3-D flow-through pre-concentrating electrode, and multiple planar sensing electrodes.

SST: Colorimetric MicroArrays for Detection of Toxic Industrial Chemicals (NSF 2005 Continuing Grant)

Award Number: 0528499

September 15, 2005 to August 31, 2007

Awarded Amount to Date: \$167,874

Kenneth Suslick (PI) ksuslick@uiuc.edu

University of Illinois at Urbana-Champaign 217/333-2187

This project will continue productive work in the PI's laboratory on cross-reactive colorimetric sensor arrays to detect toxic industrial chemicals (TICs) in air and water matrices. The work has three goals: (1) miniaturization of a colorimetric array and array reader; (2) quantitative characterization of the sensitivity and response time of colorimetric micro-arrays to trace levels of TICs in the gas phase; and (3) quantitative characterization of the sensitivity and response time of colorimetric micro-arrays to trace levels of TICs in water. Arrays previously developed by the PI for TICs in air are inexpensive, sensitive, and selective; this project will develop techniques to fabricate much smaller and well-controlled dye spots and miniaturize the scanner that reads the arrays.

SST: Integrated Multi-Analyte Microelectrode Array Sensors for In Situ Environmental Monitoring (NSF 2005 Standard Grant)

Award Number: 0529217

October 1, 2005 to September 30, 2008

Awarded Amount to Date: \$334,787

Ian Papautsky (PI) ipapauts@ececs.uc.edu; Paul Bishop (Co-PI); Fred Beyette (Co-PI)

University of Cincinnati, Cincinnati, OH 513/556-2870

This project will develop a solid-state microelectrode sensor for inorganic phosphate using a cobalt oxide matrix. The sensor will be combined with analogous microsensors for redox potential and pH to form multi-analyte sensor arrays on a CMOS signal-processing chip. The sensor will be characterized in terms of calibration curves, stability and reproducibility of measurements, detection limits, and response times. The long-term goal is to develop integrated microelectrode array sensors for in situ monitoring of water quality that surpass current sensing tools in capabilities and greatly decrease monitoring costs.

SST: Integrated Particle Counting and Potentiometric Sensor Array for Water Quality Analysis (NSF 2005 Standard Grant)

Award Number: 0529385

September 15, 2005 to August 31, 2008

Awarded Amount to Date: \$299,994

Richard Brown (PI) brown@coe.utah.edu; Henry White (Co-PI)

University of Utah, Salt Lake City 801/581-6903

This project will develop a new method of particle analysis based on electrophoretic capture and release of particles by nanopores. The proposed particle sensor array will be an all-electronic, mass-fabricated CMOS-integrated device, and it will be orders of magnitude smaller than current particle-measuring devices. Preliminary results demonstrate that particle capture time for a given pore is related to the concentration of particles larger than the pore diameter. Fundamental studies will characterize particle capture and release dynamics of the nanopores as a function of electrode excitation schemes. A manufacturing process will be developed to fabricate nanopores on top of CMOS circuitry. The sensor thus developed could be used to test for particles in water or to test water into which airborne particles have been collected. Particle measurements are useful in assessing water quality for a variety of practical reasons. The approach being developed by the PIs is novel and represents "cutting edge" nano-science.

## **U.S. Geological Survey Water Resources Research Institute**

A Real-Time Permittivity Sensor for Simultaneous Measurement of Multiple Water-Quality Parameters (2006 USGS WRI Research Grant)

Naiqian Zhang; Philip Barnes; Gerard Kluitenberg; Andre Ziegler, Kansas State University

Project ID: 2005KS40B

03/01/2006 - 02/28/2007

Federal Funds: \$23,000

Non-Federal Matching Funds: \$48,276

This is the continuation of an existing KWRI project. The objective is to develop a novel, frequency-response-based permittivity sensor to detect and measure the concentrations of several types of pollutants in surface water and groundwater. Since March 2003, researchers have designed and fabricated the sensor and associated signal conditioning, processing, and control

circuit. The sensor uses a cascaded-electrode structure to enlarge the capacitive effect. The hardware includes a signal generator board, a gain and phase-detector board, and a microcontroller to control the boards. Lab tests were conducted to observe the frequency response (gain and phase) of different types of waters--lake, stream, tap, and distilled--and air. Significant differences were observed in both gain and phase responses. For waters, the differences were found mainly in frequencies below 35 MHz; however, between two different types of dielectric materials, such as water and air, the differences can be seen throughout the 200 Hz-120 MHz frequency range tested, thus providing a clear indication that the sensor is capable of detecting differences in dielectric properties. Water samples with different combinations of soil sediment and salt (KCl) concentration levels were tested using a circulation system that provided uniform sediment concentrations. The sensor accurately measured KCl concentrations at each sediment concentration level. For sediment concentration measurement, the sensor only gave accurate measurement in water without added KCl and with KCl concentration of higher than 5.000 mg/L. For simultaneously measurement, the R-square values reached 0.86 and 0.87 for KCl and sediment, respectively. In year 2, a systematic experiment will be conducted in laboratory to test the sensor with different types and amounts of sediments, nutrients, and pesticides. These parameters will be measured separately to study effects of different pollutants on the conductive and capacitive behaviors. Combinations of the parameters will be measured simultaneously using prediction models established based on the frequency-response data. Various pattern-recognition methods, including statistical multivariate analyses and neural networks, will be used to establish the prediction models. Field tests will be conducted at existing USGS real-time continuous stream and lake monitoring installations with the cooperation of USGS water quality specialists. Based on experiences obtained from the laboratory and field tests, the sensor's structure will be further improved to enhance portability and ease of use. The hardware will be modified to reduce the effect of parasitic impedance that might affect high-frequency performance. Options for data storage and transmission will be investigated, such as real-time transmission to the Internet through a commercial wireless phone system.

#### Rapid and Sensitive Determination of Bacteria in Water Using Nanoparticles (2006 USGS WRRRI Research Grant)

Julia Xiaojun Zhao, PI, University of North Dakota.

Project ID:2006ND98B

03/01/2006 - 02/28/2007

Federal Funds: \$14,400

Non-Federal Matching Funds: \$28,800

Bacteria can grow or re-grow in distribution systems of drinking water. In fact, potable water is a major source of some bacteria colonization, e.g., *L. pneumophila* and *E. coli*. *L. pneumophila* in potable water can replicate rapidly and increase in virulence. Given the low infectious dose of pathogenic bacteria, the presence of even a single bacterium in potable water may pose a serious health risk; hence, sensitive and rapid detection of bacteria in water is critical. The current definitive method for the detection of bacteria is the culture of the organism, which requires about 24 hours for bacterial growth. The method is too slow to meet the public need. The PCR-based method can detect bacteria within six hours, but the method requires pre-enrichment of the target bacteria. The proposed method will be able to identify target pathogenic bacteria specifically at a single bacterium level within 30 minutes in water samples. The objective of this proposal is to develop a rapid and ultrasensitive method for the specific

identification and quantitative determination of pathogenic bacteria in water. The major feature of the proposed method is the employment of fluorescent nanoparticles as target bacteria identifiers that could emit strong fluorescent signals. The method will be accurate, rapid and sensitive to meet the public need.

Development of a Novel Hydrogel-Based Sensor for the Detection of Biological Contaminants  
(2006 USGS WRI Research Grant)

Cyndee Gruden, University of Toledo

Project ID:2006OH35B

03/01/2006 - 02/28/2007

Federal Funds: \$20,402

Non-Federal Matching Funds: \$40,819

The goal of this study is the synthesis and performance evaluation of a novel selective hydrogel-based sensor for the detection of biomolecules in surface waters. The project will polymerize aptamers into an acrylamide hydrogel to develop a selective sensor. The selective hydrogel produced will permit size and shape selectivity, as well as binding specificity. Hydrogel properties will minimize non-specific binding through modulated shrinking and swelling to remove competitive molecules. Because of the complexity of environmental samples, a robust sensor must be developed that enables separation of the target from potential interferents. Current technology allows for specific detection of biomolecules. Existing methods, however, do not function adequately in environmental samples and often require amplification to achieve the required sensitivity. Thus far, these limitations have hampered ongoing detection efforts aimed at mitigation of biological contamination. With that in mind, the goal is to develop a sensor that will allow for specific and sensitive detection of biomolecules. The hydrogel-based sensor will be adaptable to a variety of biological targets via the selection of aptamers specific to a characteristic artifact (e.g., a protein or toxin). The proposed sensor will enable (1) differentiation of closely related biomolecules, (2) rapid binding of the target biomolecule in a complex system, (3) temperature and/or light induced modulation of the hydrogel for separation from the matrix and expulsion of unbound analytes, (4) sensitive detection of the target biomolecule, and (5) adaptability of the method to other target biomolecules.

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