

Measurement & Monitoring: 28th Quarterly Literature Update & Grant Survey

The references selected for this update have been added to the searchable literature database developed for the Measurement and Monitoring Technologies for the 21st Century (21M²) Web site: www.clu-in.org/programs/21m2/litsearch.cfm

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ABSTRACTS

Application of Borehole Geophysics to Delineate Preferential Contaminant Migration Pathways in a Complex Fractured Clay/Shale Aquifer

Onderko, R.J. (Earth Tech Inc., San Antonio, TX); G. Sauer (Earth Tech Inc., Alexandria, VA); J. Peterson (Hydrogeologic Inc., Reston, VA).

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 109-129, 2008

During development of a hydrogeologic conceptual site model (HCSM) for a large chlorinated solvent plume, significant groundwater movement was determined below auger refusal depths within a shallow fractured rock aquifer. Data were available for deeper zones, but not for the zone of interest. The delineation approach utilized various borehole geophysical tools to investigate this possible preferential migration pathway. A multi-phased investigation program was developed in which multiple borehole logging tools were tested to determine the suitability and the applicability of the geophysical methods to investigate the following areas of interest: (1) the presence or absence of a significant groundwater flow horizon just below auger refusal depths; (2) the hydraulic characteristics of the system; (3) refinement of the HCSM for the shallow aquifer system; and (4) the extent of contamination and the effectiveness of the remedial measures applied at or above the auger refusal depths at the site. This investigation program developed over time; once the geophysical method suite was optimized, the investigation program was streamlined.

Application of Passive Soil Gas Technology to Determine the Source and Extent of a PCE Groundwater Plume in an Urban Environment

Clarke, J.N., D.F. Goodwin, H. O'Neill, and J.E. Odencrantz.

Remediation Journal, Vol 18 No 4, p 55-62, 2008

The cost of investigating groundwater contaminated with volatile organic compounds increases with the number and depth of borings and the number of samples collected and analyzed. An environmental investigator and the Arizona Department of Environmental Quality successfully used passive soil gas (PSG) surveys in Arizona to investigate volatile organic impacts to groundwater and identify potential sources of impact cost effectively. PSG surveys are minimally intrusive, and more samples can be collected for the same cost when compared to active soil gas surveys and conventional soil and groundwater sampling programs. The result is a surficial representation of the contaminant plume and the location of hot spots (the potential sources). This result provides a better understanding of the nature and extent of the impact and allows for a focused subsurface investigation, which subsequently reduces drilling and sampling costs. http://www.beacon-usa.com/pdf/Regional_Groundwater_Investigation.pdf

Assessing Natural Attenuation of a PCE-Contaminated Aquifer Using a Combined CSIA and Groundwater Dating Approach

Aeppli, C., H. Amaral, M. Berg, and R. Kipfer (Swiss Federal Inst. of Aquatic Science and Technology, Dübendorf); T.B. Hofstetter and R.P. Schwarzenbach (Inst. of Biogeochemistry and Pollutant Dynamics, ETH Zurich, Switzerland). 18th Annual V.M. Goldschmidt Conference, 13-18 July 2008, Vancouver, Canada. Abstracts, p A5, 2008

The combination of compound-specific stable isotope analysis (CSIA) with groundwater dating provides in situ determination of degradation rates. This information is essential for assessing the natural attenuation potential of contaminated aquifers. The authors conducted an investigation of a former drycleaning site contaminated with PCE to test this approach. Because definition of the contamination plumes and flow pathways was inhibited by almost stagnant hydrogeological conditions and considerable aquifer heterogeneity, groundwater dating (the 3H - 3He method) was necessary to assess this site. The presence of degradation products, active PCE-degrading microcosms, and the results of biomolecular analysis of field sediments provided clear evidence of attenuation activity. Carbon isotopic signatures of PCE were used to quantify biodegradation using the Rayleigh model. Together with groundwater residence times, a first-order degradation rate of PCE transformation of $k = 0.2/\text{y}$ was estimated. The evaluation of the total isotopic signature of PCE and its degradation products also allowed assessment of the total PCE detoxification potential. A simple 1-D reactive transport model was used to support these results.

Assessment and Remediation of Vapor Intrusion to Indoor Air, South Mesa State Superfund Site, Gilbert, Arizona

Clarke, J.N. (MACTEC Engineering and Consulting, Phoenix, AZ); H. O'Neill (Beacon Environmental Service, Inc., Bel Air, MD); J.E. Odencrantz (Beacon Environmental Service, Inc., Newport Beach, CA).

Proceedings of the Sixth International Battelle Conference: Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California May 19-22, 2008. Battelle Press, 7 pp, 2008

The authors describe the implementation of a cost-effective, three-phase approach to assess the vapor intrusion to indoor air pathway at the South Mesa Water Quality Assurance Fund (Arizona State Superfund) Registry site in Gilbert, Arizona. The vapor intrusion assessment involved five phases: (1) surface geophysical survey; (2) passive soil vapor survey; (3) collection of discrete soil and soil gas samples from deep borings; (4) collection of discrete soil and soil gas samples from shallow borings; and, (5) collection of indoor air quality (IAQ) samples. The passive soil-vapor survey proved to be a cost effective, rapid, and accurate method to delineate the areal extent of the vadose zone impact and identify possible source areas. The passive soil vapor survey also indicated the area of the site where vapor intrusion was a potential exposure pathway. The follow-up depth-specific soil gas and IAQ sampling programs confirmed the passive soil vapor survey results.

http://www.beacon-usa.com/pdf/Vapor_Intrusion_and_Source_Investigation.pdf

Assessment of Diesel Contamination in Groundwater Using Electromagnetic Induction Geophysical Techniques

Jin, S., P. Fallgren, J. Cooper, and J. Morris (Western Research Institute, Laramie, WY); M. Urynowicz (Univ. of Wyoming, Laramie).

Journal of Environmental Science and Health, Part A, Vol 43 No 6, p 584-588, May 2008

An electromagnetic induction survey was investigated as an alternative technique for mapping petroleum contaminants in the subsurface. The surveys were conducted at a coal mining site near Gillette, WY, using the EM34-XL ground conductivity meter. Data from this survey were validated with known concentrations of diesel compounds detected in groundwater from the study site. Groundwater data correlated well with the electromagnetic survey data, which was used to generate a site model to identify subsurface diesel plumes. The results indicate that this geophysical technique can be an effective tool for assessing subsurface petroleum hydrocarbon sources and plumes at contaminated sites.

Assessment of the Long Term Stability of Paper Sludge Covers over Mine Tailings Using Solid State NMR

Cousins, C. and G. Spiers, Laurentian Univ., Sudbury, ON, Canada.

18th Annual V.M. Goldschmidt Conference, 13-18 July 2008, Vancouver, Canada. Abstracts, p A185, 2008

The applicability of using paper sludge as an organic cover for mine wastes to prevent the oxidation of sulfide minerals by creating an anaerobic barrier is being investigated by the mining industry. The degradation of the amendments must be examined to enable prediction of their potential for long-term mine drainage prevention. Paper sludge amendments were applied over a 6-year period to mine tailings from historic gold mine operations. Samples were collected from four different properties, each a site of a historical gold mine operation. As raw paper sludge is primarily composed of lignin, chemicellulose, and cellulose, the speciation of the organic matter can be used to determine the degradation of the paper sludge and to predict the amendment's long-term stability. Speciation of the organic carbon can be determined using cross-polarized/magic angle spinning solid-state NMR, as previous work has shown that cellulose, hemi-cellulose, and lignin all have distinct chemical shifts, enabling their identification. Organic carbon speciation analysis from the NMR spectra is compared with FTIR data. Other spectroscopic techniques--CNS combustion, ICP-AES, and ICP-MS--also can be used to characterize the long-term suitability of paper sludge amendments for reclamation of gold waste materials.

Automated Analysis of Genes: Ziplex Automated Gene-Expression System, Xceed Molecular Corp., Wellesley, Mass.

R&D Daily, Oct 2008

Translational research and the ultimate goal of personalized medicine have been hampered because the available technology to process microarrays is complex, expensive, and time-consuming. Results from traditional technologies are also prone to unacceptable levels of variability in meeting the rigorous performance and quality control needs of the clinical-diagnostic laboratory. The Ziplex Automated Gene-Expression System, from researchers at Xceed Molecular Corp., Wellesley, MA, was designed with turnkey functionality and significant

advances in automation, array format, fluidics, parallel sample processing, and analytics to minimize complexity, user interaction, and variability between users and sites. It is an integrated system for automated gene-expression analysis, comprising an automated hybridization workstation, TipChip consumable arrays, reagents, and analysis/reporting software. At the core of the Ziplex system is the TipChip--a single-use disposable device consisting of a Flow-Thru Chip mounted to a polycarbonate tube. Unlike 2-D arrays, the 3-D Flow-Thru Chip design enables active transport of targets to probes. Multiple capture reagents are deposited in a grid for parallel analysis of up to 464 features, which results in hybridization times that are three to four times faster than conventional methods. This technology has been selected as an R&D 100 2008 Award Winner for Bioscience.

Azimuthal Self Potential Signatures Associated with Pneumatic Fracturing

Wishart, D. and L. Slater (Rutgers Univ., Newark, NJ); D. Schnell (Pneumatic Fracturing, Inc., Alpha, NJ); G. Herman (New Jersey Geological Society, Trenton).

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 829-832, 2008

Pneumatic fracturing is used to improve the permeability and porosity of tight unconsolidated soils, such as clays, and/or bedrock to improve the effectiveness of remediation treatments. A laboratory simulation was performed in which compressed kaolinite sediments were pneumatically fractured and subsequently injected with an electrolyte/dye, simulating a treatment. Fracture geometry was quantified via fracture strike analysis of visible fractures in the tank walls combined with optical borehole televiewer imaging. Azimuthal self-potential (ASP) measurements revealed clear electrokinetic self potentials during injection that correlate with dominant fracture strikes in the clay. Polar plots show that ASP lobes coincide with azimuths of high fracture strike density and that cross plots of SP versus number of fractures display a statistically significant positive correlation. The magnitude of electrokinetic SP scales with flow rate for any particular fracture set, and the positive lobes of the ASP anomaly are diagnostic of the flow direction of the treatment.

Bacterial Biosensors for Rapid and Effective Monitoring of Biodegradation of Organic Pollutants in Wastewater Effluents

Olaniran, A.O., R.M. Motebejane, and B. Pillay.

Journal of Environmental Monitoring, Vol 10, p 889-893, 2008

Two whole-cell bacterial biosensors were constructed by transforming competent cells of *Shigella flexneri* and *Shigella sonnei* with pLUX plasmids. The biosensors were evaluated for their potential to monitor wastewater samples undergoing degradation by measuring bioluminescence response using a microplate luminometer. Both bacterial biosensors exhibited extremely sensitive responses to wastewater samples, with different patterns, concomitant with those of the chemical oxygen demand removals demonstrated at the different points in the degradation process. Generally higher bioluminescence values were obtained at the later days of the degradation period compared to the initial values, and a steady decrease in bioluminescence was observed for the bacterial biosensors with increasing time of exposure to the wastewater effluent.

Biosensor for Direct Determination of Fenitrothion and EPN Using Recombinant *Pseudomonas putida* JS444 with Surface-Expressed Organophosphorous Hydrolase. 2. Modified Carbon Paste Electrode

Lei, Y. (Univ. of Connecticut, Storrs); P. Mulchandani, W. Chen, and A. Mulchandani (Univ. of California, Riverside),

Applied Biochemistry and Biotechnology, Vol 136, p 243-250, 2007

The authors present a whole cell-based amperometric biosensor for highly selective, sensitive, rapid, and cost-effective determination of the organophosphate pesticides fenitrothion and ethyl p-nitrophenol thiobenzenephosphonate (EPN). The biosensor comprises genetically engineered p-nitrophenol (PNP)-degrading bacteria *Pseudomonas putida* JS444 anchoring and displaying organophosphorous hydrolase (OPH) on its cell surface as a biological sensing element and carbon paste electrode as the amperometric transducer. Surface-expressed OPH catalyzed the hydrolysis of organophosphorous pesticides such as fenitrothion and EPN to release PNP and 3-methyl-4-nitrophenol, respectively, which subsequently were degraded by the enzymatic machinery of *P. putida* JS444 through electrochemically active intermediates to the TCA cycle. The electrooxidization current of the intermediates was measured and correlated to the concentration of organophosphates. Operating at optimum conditions, 0.086 mg dry wt of cell operating at 600 mV of applied potential (vs Ag/AgCl reference) in 50 mM citratephosphate buffer, pH 7.5, with 50 μ M CoCl₂ at room temperature, the biosensor measured as low as 1.4 ppb of fenitrothion and 1.6 ppb of EPN with no interference from phenolic compounds, carbamate pesticides, triazine herbicides, or organophosphate pesticides without nitrophenyl substituent. The service life of the biosensor and its applicability to lake water are also described. <http://www.engr.ucr.edu/~wilfred/>

Calibration and Use of the Chemcatcher(r) Passive Sampler for Monitoring Organotin Compounds in Water

Aguilar-Martinez, R. and M.A. Palacios-Corvillo (Univ. Complutense of Madrid, Spain); R. Greenwood, G.A. Mills, B. Vrana, and M.M. Gomez-Gomez.

Analytica Chimica Acta, Vol 618 No 2, p 157-167, June 2008

An integrative passive sampler (Chemcatcher(r)) consists of a 47 mm C18 Empore disk as the receiving phase overlaid with a thin cellulose acetate diffusion membrane. This sampler was calibrated for the measurement of time-weighted average water concentrations of organotin compounds in water. The effect of water temperature and turbulence on the uptake rate of these analytes was evaluated in the laboratory using a flow-through tank. Uptake was linear over a 14-day period for all the different conditions tested. The sampling rates were high enough to permit the use of the Chemcatcher(r) to monitor levels of organotin compounds typically found in polluted aquatic environments. Using gas chromatography (GC) with either ICP-MS or flame photometric detection, limits of detection for the device (14-day deployment) for the different organotin compounds in water were in the range of 0.2 to 7.5 ng/L. Once accumulated in the receiving phase, the compounds were stable over prolonged periods. Due to anisotropic exchange kinetics, performance reference compounds could not be used with this passive sampling system to compensate for changes in sampling rate due to variations in water temperature, turbulence, and biofouling of the surface of the diffusion membrane during field deployments. The performance of the Chemcatcher(r) was evaluated alongside spot water

sampling in an area known to contain elevated levels of organotin compounds. The samplers provided time-weighted average concentrations of the bioavailable fractions of the tin compounds where environmental concentrations fluctuated markedly in time.

Canisters v. Sorbent Tubes: Vapor Intrusion Test Method Comparison

Odencrantz, J.E. (Beacon Environmental Services, Newport Beach, CA); H. O'Neill (Beacon Environmental Services, Bel Air, MD); J.T. Kirkland (Professional Consulting Corp., Gaithersburg, MD).

Proceedings of the Sixth International Battelle Conference: Remediation of Chlorinated and Recalcitrant Compounds, May 19-22, 2008, Monterey, California. Battelle Press, 7 pp, 2008

The design of a field vapor-intrusion investigation consisted of three 1-ft deep borings spaced 1 ft apart at three locations within the perimeter of a former dry cleaner. One 6-L Summa canister (EPA Method TO-15) and two pump/packed tube assemblies (EPA Method TO-17) were used in each three-boring arrangement for a total of nine sampling locations. A length of Teflon(r) tubing one quarter-inch in diameter was lowered into the hole until it was approximately 1 inch from the bottom. The tubing had a screen frit (implanted prior to field work) in the end lowered down the hole to prevent the uptake of particle matter. The end of the tubing extending above ground had a stainless steel valve that had been swaged to it prior to sampling. Eight-hour tests were conducted at a gas flow rate of approximately 10 mL/min. The results of the field comparisons compared exceptionally well (R-squared = 0.98 for PCE) on a relative concentration basis from location to location for PCE, TCE, and 1,2-DCE (reported concentration range: 3.7-22,200 ug/m³). A comparison of the concentrations measured by each method revealed a linear relationship between molecular weight and the difference in concentration between the two methods. The TO-17 results were between 0.27 and 0.67 times lower than the TO-15 results on a consistent basis for PCE. The authors believe the major factors contributing to the differences are flow rates of sample collection, moisture effects and dilution procedures with the TO-15 method. Subsequent indoor air testing inside the structure allowed attenuation factor calculations for PCE that varied from 0.05 to 0.002 across the site.

http://www.beacon-usa.com/pdf/Soil_Gas_Method_Comparison.pdf

Caulobacter crescentus as a Whole-Cell Uranium Biosensor

Hillson, N.J. (Stanford Univ., Stanford, CA); P. Hu and G.L. Andersen (Lawrence Berkeley National Lab, Berkeley, CA); L. Shapiro (Stanford Univ.).

Applied and Environmental Microbiology, Vol 73 No 23, p 7615-7621, Dec 2007

An engineered strain of the bacterium *Caulobacter crescentus* fluoresces in the presence of micromolar levels of uranium at ambient temperatures when it is exposed to a hand-held UV lamp. The authors constructed a reporter that utilizes the *urcA* promoter to produce a UV-excitable green fluorescent protein in the presence of the uranyl cation, a soluble form of uranium. This reporter is specific for uranium and has little cross specificity for nitrate, lead, cadmium, or chromium. The uranium reporter construct was effective for discriminating contaminated groundwater samples (4.2 uM uranium) from uncontaminated groundwater samples (<0.1 uM uranium) collected at the Oak Ridge Field Research Center. In contrast to other uranium detection methodologies, the *Caulobacter* reporter strain can provide on-demand

usability in the field; it requires minimal sample processing and no equipment other than a hand-held UV lamp; and it can be sprayed directly on soil, groundwater, or industrial surfaces.

<http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2168040>

Characterization of a Petroleum Hydrocarbon Release by Laser-Induced Fluorescence and its Use in Guiding Remedial Strategy

Martinek, B., Cameron-Cole, LLC.

2007 Railroad Environmental Conference, October 23-25, 2007: Presentation abstracts.

Illinois Railroad Engineering Program, p 16, 2007

The occurrence of separate-phase hydrocarbons (SPH) in vadose and saturated zone soils at release sites can dominate the ground-water environment through the perpetuation of dissolved-phase contamination. Typically, treatment or removal of the SPH at a hydrocarbon release site is a prerequisite for successful remediation, but it often is difficult to determine precisely where the SPH resides in the formation so that remediation technologies can target the contamination effectively. Laser-induced fluorescence (LIF) is a rapid screening technology that can provide sensitive and high-resolution delineation of subsurface SPH contamination. LIF technology provides detection of hydrocarbons due to their fluorescence emitted in response to specific wavelengths of ultraviolet light delivered by a laser. Subsurface measurements are achieved by fitting the laser to a downhole tool, typically a cone penetrometer. This configuration can achieve a detailed vertical profile of approximately 12 readings per foot and 300 feet per day. At a former petroleum refinery site, the lateral extent of SPH in a sand aquifer overlain by a silt-clay layer previously was well defined at the site by an extensive network of monitoring wells. Little was known, however, about the vertical distribution of SPH. The conceptual model indicated initially that SPH occurred predominantly in the smear zone across the upper silt-clay layer, with the lower, more permeable sand impacted by a dissolved-phase plume. LIF data collected at 28 locations within the center and margins of the affected area provided detailed vertical profiling of the occurrence of SPH throughout the vadose and saturated zones. These data showed that SPH occurred throughout the vertical extent of the sand aquifer, well below the water table. The results of the LIF investigation significantly altered the conceptual model and shifted the focus of remediation from the silt-clay layer to the more readily treatable sand where the majority of the SPH resided.

Characterization of Near-Road Pollutant Gradients Using Path-Integrated Optical Remote Sensing

Thoma, E.D. and R.C. Shores (U.S. EPA); V. Isakov (NOAA); R.W. Baldauf (U.S. EPA).

Journal of the Air & Waste Management Association, Vol 58 No 7, July 2008

In July and August of 2006, a field study of various air-polluting compounds emitted by road traffic was conducted near Interstate 440 in Raleigh, NC. Measurements of nitric oxide (NO) were facilitated by the use of a novel path-integrated optical remote-sensing technique: deep ultraviolet differential optical absorption spectroscopy (DUV-DOAS). This paper reviews the development and application of this measurement system and presents the benefits of path-integrated measurements for assessing line source-impacts and evaluating models. The advantages are also discussed of NO as a tracer compound compared with nitrogen dioxide for investigations of mobile source emissions and initial dispersion under crosswind conditions.

Characterizing Groundwater Using Controlled Source Audio Frequency Domain Magnetics
Montgomery, J. and V.O. Kofoed, Willowstick Technologies, LLC, Draper, UT.

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 969-972, 2008

The minimally invasive imaging procedure detailed in this presentation generates accurate groundwater maps and models while requiring significantly less drilling than traditional characterization approaches, with concomitantly fewer costs in terms of time, money and ecological disruption. Initial case studies indicate that this procedure may be particularly well suited to the task of environmental remediation. The procedure relies on the principles of controlled source-audio frequency domain magnetics (CS-AFDM). Electrodes charge the groundwater in question with a low voltage electrical current. As the current passes through the water between the electrodes, it emits a magnetic field whose size, shape, magnitude, and direction are characteristic of the surrounding aqueous system. The field then is read at the surface by a specially tuned receiver, ultimately resulting in maps and models that indicate the attributes of the subsurface water network, including potential flow paths.

Chemcatcher(r) and DGT Passive Sampling Devices for Regulatory Monitoring of Trace Metals in Surface Water

Allan, I.J., J. Knutsson, N. Guigues, G.A. Mills, A.M. Fouillac, and R. Greenwood.
Journal of Environmental Monitoring, Vol 10 No 7, p 821-829, July 2008

Monitoring programs that ensure compliance with regulatory standards generally use spot-sampling techniques to measure levels of trace metals, but based on results of a recent study, scientists recommend combining spot sampling with data taken from devices that remain in the water for a number of weeks. Researchers from France, Norway, Sweden, and the UK tested trace metal concentrations in the River Meuse in the Netherlands using two different sampling devices and compared the results to those obtained from spot samples. A major problem with spot sampling is that it does not take account of variations in pollutant concentrations that occur in the periods between samples. Estimates of metal concentrations can be improved by sampling more often, but this can prove time consuming and expensive. The new research shows that monitoring devices that accumulate metal over longer periods can provide useful estimates of metal concentrations, which compare well with data from high-frequency spot samples. The two devices tested, Chemcatcher(r) and the diffuse gradient in thin film (DGT) sampler, both provided reliable estimates of cadmium and nickel concentrations, as well as copper and zinc; however, the researchers suggest further adjustments need to be made to the devices to improve lead sampling. The study was carried out using devices that remained in the water for between one and four weeks. More research needs to be carried out to establish optimum exposure times for obtaining accurate data. A question also remains over the effects of the specific characteristics of a body of water on the devices. The River Meuse, for example, is a "hard water" source in that it contains high levels of calcium carbonate. Further studies should address the impact of different conditions on the accuracy of sample data.

Chemical/Bio Sensor with Carbon Nanotube and Plasma-Polymerized Film: Optimization of Loading Concentration of Carbon Nanotube

Matsui, Y., T. Hoshino, M. Yoshizawa, and H. Muguruma, Shibaura Inst. of Technology, Tokyo. Chemical Sensors, Vol 24, Supplement A, 2008 [Proceedings of the 45st Chemical Sensor Symposium, March 29-31, 2008]

A novel electrochemical (chemical and biochemical) sensor is based on carbon nanotubes (CNT) and plasma-polymerized film (PPF). The CNTs were sandwiched with 2 nm-thick acetonitrile PPFs. The PPF underlayer was deposited onto a sputtered gold electrode. The CNT concentration was optimized for casting formation onto the PPF underlayer. The nicotin adenine dinucleotide (NADH) sensor showed high sensitivity (a sensitivity of 240 mA/mM/cm², a correlation coefficient of 0.993, a linear response range of 0.009-2.3 mM, a detection limit of 3.9 mM at S/N=3, +0.4 V vs Ag/AgCl), and rapid response (< 7 s in reaching 95% of maximum response). The glucose biosensor also showed ultrasensitivity (40 mA/mM/cm², a correlation coefficient of 0.992, a linear response range of 0.025-1.9 mM, a detection limit of 6.2 mM at S/N=3, +0.8 V vs Ag/AgCl), and rapid response (< 4s in reaching 95% of maximum response). This high performance is attributed to the excellent electrocatalytic activity and enhanced electron transfer that CNTs offer. The PPF and/or plasma process for CNTs is an electrochemistry-friendly platform.

Colour Coded Bacteria Can Spot Oil Spills or Leaky Pipes and Storage Tanks

Innovation News, 11 Sep 2008

In the future, oil spills and leaks could be spotted quickly and easily using color-coded bacteria. The simple, single-celled bodies of bacteria are relatively easy to equip with a sensor and a brightly colored 'reporter protein' that shows up under a microscope, alerting the viewer to different substances leaking into soil or water from oil spills, agricultural chemicals, or other pollutants. Professor Jan Van der Meer from the University of Lausanne in Switzerland has found sensing bacteria are very simple to maintain, and tests with the bacteria are extremely easy to carry out. Tests by Van der Meer's group and checks by other laboratories have shown that pollution testing using bacteria is a remarkably robust technique and produces reliable results. The bacteria reproduce themselves in a growth medium, which makes the whole setup very inexpensive. The new technique has been tested successfully in research at sea, where the scientists demonstrated that the bacteria could measure different chemicals seeping from oil into the water, showing up as the blue light of bioluminescence in a simple light recording device. These relatively simple and cheap assays could be used as a first line of defence to judge contamination in the environment. Once positive values are obtained, more in-depth studies can be performed using chemical analysis. Technical research in this field is heading towards miniaturized sensors which can incorporate many different bacteria types, each of which responds to a different chemical. These miniaturized sensors could be used for rapid screening of samples with unknown compositions, such as water samples, but air could also be monitored for proper quality. In stand-alone systems, such as buoys, bacteria sensors could screen the presence of polluting compounds continuously. The main problem with detecting oil spills and other toxic compounds currently is that many of the most dangerous chemicals do not dissolve in water very well, making them difficult to detect. These oils also have a strong tendency to stick to surfaces like rocks, where they can remain for many years, making it tricky to detect small leaks or ancient sources of pollution. The bacteria can detect different mass transfer rates of the pollutants

and indicate how the pollution is spreading. http://www.innovations-report.com/html/reports/environment_sciences/colour_coded_bacteria_spot_oil_spills_leaky_pipes_117933.html

Comparision of nirS, cnorB, MCR Genes against Water Quality Parameters to Monitor Uncontrolled Landfills

Park, H.A., J.S. Han, and C.G. Kim, Inha Univ., Incheon, Korea.
Environmental Technology, Vol 29 No 7, p 785-796, July 2008

A study was conducted to investigate the possible relationship between a molecular biological investigation and water quality parameters in monitoring groundwater pollution at the immediate boundary of two closed, uncontrolled landfills. The diversity of the microbial community was characterized, and three specific genes--nirS (nitrite reductase coding gene), cnorB (nitric oxide reductase coding gene), and MCR (methyl coenzyme M reductase coding gene)--were quantified. The quantified genes were then compared with conventional water quality parameters. From the analyzed DNA sequences, Proteobacteria phylum was most dominantly observed. A quantitative analysis revealed that the copy numbers (gene abundance) of denitrification enzyme coding genes (i.e., nirS gene and cnorB gene in J site) are 7 and 4 times, higher, respectively, than T site. This simply implied that denitrification was possibly higher in J site than T site. In addition, a methane production enzyme coding gene (i.e., MCR) in a J1 bore immediately bordering the sources in the J site showed the greatest concentration, but it decreased precipitously in the downgradient direction toward the outer boundary of landfill. A comparative investigation between the copy numbers of the three genes and conventional monitoring parameters showed that they had overall correlation as given by more than 0.99 of the squared correlation coefficient for almost all of the concerned bores. The investigators concluded that the comparison between the molecular biological investigation and the conventional groundwater monitoring parameters showed a good relationship. Together, both tools could be used for assessing the levels of contamination efficiently and predicting the fate of pollutants, rather than being applied separately.

Comparison of Twelve Dielectric Moisture Probes for Soil Water Measurement under Saline Conditions

Inoue, M., B.A. Ould Ahmed, and M. Irshad.

American Journal of Environmental Sciences, Vol 4 No 4, p 367-372, 2008

Selecting the type of system that should be used for soil water measurement under saline conditions depends on its precision. A laboratory study was carried out to measure soil water content and soil solution electrical conductivity using 8 portable dielectric moisture probes namely and four profile probes. Air-dried Tottori sand dune soil was made saline by applying NaCl solutions of varying concentrations. The output results of moisture probes showed that measurement accuracy was strongly dependent on the concentration of salt in the soil. The authors report the performance of the 8 sensors under varied conditions. Among the moisture meters, 4 commercially available units provided sufficient accuracy in the presence of salts.
<http://www.scipub.org/fulltext/ajes/ajes44367-372.pdf>

Construction and Comparison of Fluorescence and Bioluminescence Bacterial Biosensors for the Detection of Bioavailable Toluene and Related Compounds

Li, Y.F., F.Y. Li, C.L. Ho, and V.H. Liao, National Taiwan Univ., Taipei, Taiwan.

Environmental Pollution, Vol 152 No 1, p 123-129, Mar 2008

The authors constructed toluene bacterial biosensors comprised of two reporter genes, *gfp* and *luxCDABE*, characterized by green fluorescence and luminescence, respectively, and compared their abilities to detect bioavailable toluene and related compounds. The bacterial luminescent biosensor allowed faster and more sensitive detection of toluene; the fluorescent biosensor strain was much more stable and thus more applicable for long-term exposure. Both luminescent and fluorescent biosensors were field tested to measure the relative bioavailability of BTEX in contaminated groundwater and soil samples. The estimated BTEX concentrations determined by the bacterial biosensors were closely comparable. The results indicate that both bacterial luminescent and fluorescent biosensors are useful in determining the presence and the bioavailable fractions of BTEX in the environment.

Correlation between Electrical Resistivity and Moisture Content of Municipal Solid Waste in Bioreactor Landfill

Grellier, S., K.R. Reddy, J. Gangathulasi, R. Adib, and C.C. Peters.

Geo-Denver 2007: New Peaks in Geotechnics. ASCE, Reston, VA.

The changes in electrical resistivity of municipal solid waste (MSW) measured with electrical resistivity tomography (ERT) have been used to assess the influence of leachate recirculation events at bioreactor landfills. An attempt is made in this study to develop a direct correlation between the electrical resistivity and the moisture content of MSW. This correlation is based on a field testing program at Orchard Hills landfill (Illinois, USA) that included (1) ERT at three different locations that have been subjected to leachate recirculation events, and (2) moisture content of waste samples obtained at different depths from boreholes at the same three locations of ERT. It is shown that Archie's law can reasonably correlate the electrical resistivity and the moisture content of the waste; however, the two parameters, a and m , needed for the correlation appear to depend on the specific waste conditions. For the studied waste, the best fitted parameter a is 0.75 and the parameter m ranges from 1.6 to 2.15. Using this correlation, the influence of leachate recirculation on the distribution of moisture content at three locations of the landfill is evaluated. This study shows that the ERT can be a useful noninvasive technique to monitor the moisture content of MSW and to assess the effectiveness of recirculation systems at bioreactor landfills.

Coupling Micro-Raman and Microscanning X-Ray Diffraction to Characterize Heterogeneous Material

Courtin-Nomade, A. and M. Vanaecker (Univ. of Limoges, France); M. Kunz and N. Tamura (LBNL, Berkeley, CA).

18th Annual V.M. Goldschmidt Conference, 13-18 July 2008, Vancouver, Canada. Abstracts, p A185, 2008

A large, formerly mined sulfide deposit in which the association of pyrite, chalcopyrite, sphalerite, and galena dominated has been weathered under supergene conditions, leading to the formation of highly heterogeneous secondary phases, closely mixed at a scale ranging from 10 to

50 μm . Due to their small size, those minor phases have been identified using synchrotron-based micro-scanning x-ray diffraction (uSXR) coupled to conventional micro-Raman acquisitions. Micron-scale resolved techniques enable the relationships between the various mineral phases to be deciphered, thus identifying the carriers of potentially toxic metals such as Cu or Pb and enabling a forecast of how the environment of the mining district will be affected.

Cr Isotopes Reveal Progress of Natural Reduction of Contaminant Cr(VI) in a Groundwater System

Johnson, T.M. and E. Berna, Univ. of Illinois at Urbana-Champaign.

18th Annual V.M. Goldschmidt Conference, 13-18 July 2008, Vancouver, Canada. Abstracts, p A437, 2008

Mass-dependent kinetic isotope fractionation occurs during reduction of Cr(VI) to Cr(III). $^{53}\text{Cr}/^{52}\text{Cr}$ measurements may provide a quantitative indicator for the extent of reduction, which renders toxic, mobile Cr(VI) immobile and relatively innocuous. Previous studies have given fractionation factors for Cr(VI) reduction in the laboratory; now the approach is being developed in field settings. This presentation describes results from a multi-year study of an urban Cr(VI) plume managed with a combination of monitored natural attenuation and injection of reductant. Groundwater near the contaminant source and in the high-Cr(VI) core of the plume shows less reduction than more distal groundwater, which suggests that the reducing capacity of matrix materials is diminished in the plume core. The average temporal trend in $\delta^{53}\text{Cr}$ is weakly positive, with erratic variation in a few wells. The isotope data and longer-term concentration trends both are consistent with slow natural attenuation of Cr(VI), occurring mostly within the fringes of the plume. While temporal and spatial trends in $\delta^{53}\text{Cr}$ are very informative qualitatively, accurate and precise quantitative determinations of the extent of reduction require further study.

Cyanide Speciation at Four Gold Leach Operations Undergoing Remediation

Johnson, C.A. (USGS, Denver, CO), D.J. Grimes, R.W. Leinz, and R.O. Rye.

Environmental Science & Technology, Vol 42 No 4, p 1038-1044, 15 Feb 2008

Analyses were made of effluents from four gold leach operations in various stages of remediation to identify the most persistent cyanide species. Total cyanide, weak acid-dissociable (WAD) cyanide, and metals known to form stable cyanocomplexes were measured using improved methods. Total cyanide typically exceeded WAD significantly, indicating that cyanide was predominantly in strong cyanometallic complexes. Iron generally was too low to accommodate the strongly complexed cyanide as $\text{Fe}(\text{CN})_6^{3-}$ or $\text{Fe}(\text{CN})_6^{4-}$, but cobalt was abundant enough to implicate $\text{Co}(\text{CN})_6^{3-}$ or its dissociation products ($\text{Co}(\text{CN})_6^{3-x}(\text{H}_2\text{O})_x^{(3-x)-}$). Supporting evidence for cobalt/cyanide complexation was found in tight correlations between cobalt and cyanide in some sample suites. Also, abundant free cyanide was produced upon UV illumination. Iron and cobalt cyanocomplexes both photodissociate; however, the iron concentration was insufficient to have carried the liberated cyanide, while the cobalt concentration was sufficient. Cobalt cyanocomplexes have not been recognized previously in cyanidation wastes. Their identification at four separate operations treating ores not especially rich in cobalt suggests that cobalt complexation may be a common source of cyanide persistence.

Delineation of an Old Coal Mine in an Urban Environment with Surface Wave Seismics Using a Landstreamer and Laterally Constrained Inversion

Wisén, R., M. Linden, and M. Svensson, Tyrens AB, Helsingborg, Sweden.

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 1403-1410, 2007

A surface wave seismic investigation was made to delineate an old coal mine. As described in old literature, the mine has an area of about 6 acres, and each layer of coal has a height of less than one m; however, the exact location and status is unclear. The sedimentary geological setting consists of fill, quaternary deposits, shale, coal and sandstone. The mine, or alternatively the coal, is found at 10 m depth between a layer of shale and a layer of soft sandstone. The seismic measurements were made along two crossing profiles, located on the walkways covered with gravel, in the area where the mine is expected. The measurement system was a landstreamer with 24 4.5 Hz geophones, a Geometrics Geode, and a shotgun. The vs models clearly show increasing velocities with depth with a low velocity layer at 10 m depth. The results correlate well with the expected geology and results from geotechnical drillings that indicate an open mine in parts of the area; however, the low velocity layer is mainly due to the soft sandstone and does not seem to be strongly affected by the presence of the open mine.

Delineation of Soil and Groundwater Contamination Using Geophysical Methods at a Waste Disposal Site in Canakkale, Turkey

Kaya, M.A., G. Ozurlan, and E. Sengul, Canakkale Onsekiz Mart Univ., Turkey.

Environmental Monitoring and Assessment, Vol 135 Nos 1-3, p 441-446, Dec 2007

Direct current (DC) resistivity, self potential (SP), and very low frequency electromagnetic (VLF-EM) measurements were carried out to detect the spread of groundwater contamination and to locate possible pathways of leachate plumes emanating from an unmanaged open waste disposal site. The catchment area borders a small creek and is topographically at a higher elevation relative to the urban area. Interpretations of DC resistivity geoelectrical data showed a low resistivity zone (<5 ohm-m) that appears to be saturated with leachate from the open dumpsite. The VLF-EM and SP methods support the results of the geoelectrical method, indicating a contaminated zone in the survey area. Good correlation was observed between the geophysical investigations and the results of previously collected geochemical and hydrochemical measurements.

Dense Resistivity and Induced Polarization Profiling for a Landfill Restoration Project at Harlov, Southern Sweden.

Leroux V., T. Dahlin, M. Svensson, Lund University, Lund, Sweden.

Waste Management Research, Vol 25 No 1, p 49-60, 2007

A resistivity and time-domain induced polarization (IP) survey was conducted at a landfill site under restoration. Covering of the landfill had begun some years previously, although precise records of the work were not kept as is customary in such procedures. The survey was conducted in two steps, on two adjacent areas. Geoelectrical sections were made first on a partly covered area that had been investigated earlier by auger drilling during restoration

work. A second area that has received its final cover then was imaged, and defects in the cover were detected and repaired. The resistivity and time-domain IP results were consistent with the results of the geotechnical drillings, and they enabled quasi-continuous mapping along the profiles. 3D visualization showed the overall consistency of the 2D lines and helped to generate a global view of the site. In spite of some ambiguities, cover and waste could be distinguished in most cases. Fine-grained cover materials could be distinguished clearly from other cover materials.

Design and Characterization of a Multisource Hand-Held Tandem Mass Spectrometer
Gao, L., A. Sugiarto, J.D. Harper, R.G. Cooks, and Z. Ouyang, Purdue University, West Lafayette, IN.

Analytical Chemistry, Vol 80 No 19, p 7198-7205, 2008

Researchers from Purdue University describe the development of the world's smallest complete mass spectrometer, a miniature version of a standard lab device to identify tiny amounts of chemicals in the environment. The hand-held MS, about the size of a shoebox, could speed the detection of bioterrorism agents, hidden explosives, and other threats. Several different versions of portable mass spectrometers have been developed over the past few decades, but the large size, weight, and inability of these older instruments to analyze a wide variety of different target molecules have limited their practical use. The new Mini 11 is about the size of a small shoebox, weighs only 9 pounds, and can be operated by remote control. Laboratory tests showed that the Mini 11 could identify the chemical composition of three commonly used commercial drugs accurately within just one minute using tandem mass spectrometry. Unlike previous portable mass spectrometers, this new instrument is capable of analyzing a wider variety of molecules, including large proteins.

Detecting Pollution with Living Biosensors: Color-Coded Bacteria Light the Way to Oil Spills at Sea

Rice, Jocelyn.

MIT Technology Review, Sep/Oct 2008

Scientists from the University of Lausanne in Switzerland have examined tiny vials of bacteria mixed with seawater for hints of fluorescent light. By analyzing how brightly the bacteria glowed, and with which colors, they are able to diagnose and characterize the early aftermath of an oil spill. Bacteria that are engineered to glow a particular color in response to a given chemical have been studied in research laboratories for decades, but only recently have they been put to practical use, as scientists adapt and deploy them to test for environmental contaminants. Sensor bacteria give faster and cheaper--if somewhat less precise--results than traditional chemical tests do, and they may prove increasingly important in detecting pollutants in seawater, groundwater, and foodstuffs. Led by environmental microbiologist Jan Van der Meer, the team created three different strains of bacteria, each tailored to sense a particular kind of toxic chemical that leeches into seawater from spilled oil. They began with different strains of bacteria that naturally feast upon these chemicals, each releasing specialized enzymes when they come in contact with their chemical of choice. By hooking up the gene for a fluorescent or bioluminescent protein to the cellular machinery that makes those enzymes, the scientists effectively created a living light switch: whenever the chemical was present, the bacteria would

glow. For each class of toxic chemical, the team used a different color protein, so they could easily determine which chemicals were present based on the wavelength of emitted light. Working with several other European labs, the research team obtained permission from the Dutch government to create a small, artificial oil spill in the waters of the North Sea. They sampled seawater at various time points after the spill, using a luminometer to measure whether sensor bacteria added to each sample had detected the corresponding chemical. Unlike traditional chemical analyses, which can take weeks and require expensive laboratory instruments, the biosensor test could be performed on site in a matter of minutes. Bacterial sensing, which is inexpensive compared with chemical methods, could be particularly useful for routine monitoring. Catching an oil leak in its earliest stages is critical for directing appropriate cleanup efforts. A spill may not leave a visible trace until after its most toxic effects have come and gone. Chemical testing likely will still be necessary, however, because the bacterial sensors give only a rough estimate of the relative amounts of each chemical class. Van der Meer ultimately hopes to incorporate the glowing bacteria into buoy-based devices for continuous monitoring. His group is developing microfluidic systems that could maintain a constant, contained population of sensor bacteria to periodically test the waters. In addition to detecting oil spills, Van der Meer's group has developed and tested a bacterial strain that detects arsenic in rice. Other potential applications include testing for pollutants in soil and groundwater.

<http://www.technologyreview.com/Energy/21383/?a=f>

Detection and Identification of Dehalococcoides Species Responsible for In Situ Dechlorination of Trichloroethene to Ethene Enhanced by Hydrogen-Releasing Compounds

Nishimura, M., M. Ebisawa, S. Sakihara, A. Kobayashi, T. Nakama, M. Okochi, and M. Yohda, Tokyo Univ. of Agriculture and Technology, Tokyo, Japan.

Biotechnology and Applied Biochemistry, Vol 51 Pt 1, p 1-7, Sep 2008

Previous studies have shown that Dehalococcoides species are responsible for the anaerobic bioremediation of chloroethene pollution. It has been thought that co-operation of several species is required for complete dechlorination to ethene. Investigators used quantitative PCR of 16 S rRNA and RDase (reductive dehalogenase) genes to examine species changes and the population of Dehalococcoides species in groundwater in which the dechlorination of TCE (trichloroethene) to ethene was enhanced by delivery of hydrogen-releasing compounds. At least two different Dehalococcoides species appeared to co-operate in the dechlorination of TCE to ethene. The results of this work support the theory that monitoring Dehalococcoides species by the presence of RDase genes as genetic markers can provide detailed information on the status of chloroethene biodegradation at a site, which can be used to improve bioremediation progress.

Detection of Subsurface Diesel Contamination using Electromagnetic Induction Geophysical Techniques

Cooper, J. and S. Jin, Western Research Institute, Laramie, WY.

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 220-230, 2007 [A briefer version of this paper appeared in the Journal of Environmental Science and Health, Part A 43(6):584-588(2008)]

Geophysical surveys were undertaken at two coal mining sites near Gillette, Wyoming, using the EM34-XL ground-conductivity meter. Surveys were conducted using 10 m and 20 m coil separations in both dipole orientations. Areas known to contain diesel contamination were shown as resistive anomalies. Samples from monitoring wells at the two sites were correlated to the survey results for validation. Data from the survey well matched the readings from sample analysis. Results from this study indicate that electromagnetic induction surveys could be an effective tool in mapping the subsurface petroleum contaminants.

Detection of Toxic Metals in Waste Water from Dairy Products Plant Using Laser Induced Breakdown Spectroscopy

Hussain, T. (National Univ. of Sciences and Technology, Rawalpindi, Pakistan); M.A. Gondal (King Fahd Univ. of Petroleum & Minerals, Dhahran, Saudi Arabia).

Bulletin of Environmental Contamination and Toxicology, Vol 80 No 6, p 561-565, June 2008

A laser-induced breakdown spectroscopy (LIBS) system was developed for determination of toxic metals in liquid samples. The system was tested for analysis of wastewater collected from a dairy products processing plant. The plasma was generated by focusing a pulsed Nd: YAG laser at 1,064 nm on wastewater samples. Optimal experimental conditions were evaluated for improving the sensitivity of the LIBS system through parametric dependence investigations. The LIBS results were then compared with the results obtained using a standard analytical technique, such as inductively coupled plasma emission spectroscopy. The evaluation of the potential and capabilities of LIBS as a rapid tool for liquid sample analysis are discussed.

Determination of the Origin of Groundwater Nitrate at an Air Weapons Range Using the Dual Isotope Approach

Bordeleau, G. (INRS-ETE, Quebec), M.M. Savard, R. Martel, G. Ampleman, and S. Thiboutot. Journal of Contaminant Hydrology, Vol 98 Nos 3-4, p 97-105, 6 June 2008

On military training ranges, high nitrate concentrations in groundwater were reported for the first time as part of the hydrogeological characterization of the Cold Lake Air Weapons Range (CLAWR), Alberta, Canada. Explosives degradation is thought to be the main source of nitrate contamination at CLAWR, as no other major source is present. Isotopic analyses of N and O in nitrate were performed on groundwater samples from the unconfined and confined aquifers; the dual isotopic analysis approach was used to increase the chances of identifying the source of nitrate. Comparison of the isotopic ratios for the groundwater samples with those in dissolved RDX samples degraded in the laboratory pointed toward a characteristic field of isotopic ratios for nitrate being derived from the degradation of RDX.

Determination of the Feasibility of Using a Portable X-Ray Fluorescence (XRF) Analyzer in the Field for Measurement of Lead Content of Sieved Soil

Markey, A.M. (Wright Patterson AFB, OH), C.S. Clark, P.A. Succop, and S. Roda.
Journal of Environmental Health, Vol 70 No 7, p 24-29 (see also 55-66), Mar 2008

The practicality of using the XRF analyzer for analysis of lead in soil samples that were sieved in the field was determined by the amount of time it took to prepare and analyze the samples in the field and by the ease with which the procedure could be accomplished on site. Another objective was to determine the effects of moisture on the process of sieving the soil. Seventy-eight samples were collected from 30 locations near 10 houses. The samples were prepared and analyzed at the locations where they were collected. Mean soil lead concentrations by XRF were 816 ppm before drying and 817 ppm after drying compared to 1,042 ppm by laboratory flame atomic absorption spectrometry (FAAS). Correlation of field-portable XRF and FAAS results was excellent for samples sieved to less than 125 micrometers, with R² values of .9902 and .992 before and after drying, respectively. The saturation ranged from 10 to 90%. At 65% saturation or higher, it was not feasible to sieve the soil in the field without a thorough drying step, since the soil would not pass through the sieve.

<http://www.thefreelibrary.com/Determination+of+the+feasibility+of+using+a+portable+X-ray...-a0177028517>

Determining the Chemical Activity of Hydrophobic Organic Compounds in Soil Using Polymer Coated Vials

Reichenberg, F., J.-A. Jonsson, and P. Mayer.
Chemistry Central Journal, Vol 2 No 8, 2008

Equilibrium sampling devices were made by coating glass vials internally with 3- to 12-um thick layers of polydimethylsiloxane (PDMS). These were filled with slurries of a polluted soil and gently agitated for 5 days. The concentrations of 7 polycyclic aromatic hydrocarbons (PAHs) in the PDMS were measured. Validation confirmed fulfilment of the equilibrium sampling requirements and high measurement precision. Finally, chemical activities of the PAHs in the soil were determined from their concentrations and activity coefficients in the PDMS.

<http://www.journal.chemistrycentral.com/content/2/1/8>

Developing and Evaluating Techniques for Localizing Pollutant Emission Sources with Open-Path Fourier Transform Infrared Measurements and Wind Data

Wu, C.-F., C.-H. Chen, and S.-Y. Chang (National Taiwan Univ., Taipei); P.-E. Chang, R.-H. Shie, L.-Y. Sung, J.-C. Yang, and J.-W. Su (Industrial Technology Research Inst., Hsin-chu, Taiwan).

Journal of the Air & Waste Management Association, Vol 58 No 10, Oct 2008

This paper presents a field evaluation of two approaches to identify pollutant emission sources with open-path Fourier transform infrared (OPFTIR) spectroscopy. The first approach combined the plume's peak location information reconstructed from the smooth basis function minimization algorithm and the wind direction data to calculate source projection lines. In the second approach, the plume's peak location was determined with the Monte Carlo methodology by randomly sampling within the beam segment having the largest path-integrated concentration.

Prior simulation studies indicated that fitting with the beta and Weibull basis functions generally gave better estimates of the peak locations than with the normal basis function when the plumes were mainly within the OP-FTIR's monitoring line. For plumes that were symmetric to the peak position or spread over the OP-FTIR, however, fitting with the normal basis function gave better performance. In the field, two tracer gases were released simultaneously from two locations. The OP-FTIR collected data downwind from the sources with a maximum beam path length of 97 m. Both evaluated in this study may provide near real-time location estimates of air pollutant emissions and would be useful for monitoring large spatial areas (e.g., industrial complexes or hazardous waste sites). Used as screening tools, the techniques would enable investigators to narrow the potential areas in which to search for source(s), followed by the use conventional tools, such as photoionization detectors, for detailed surveys.

Development and Application of the Needle Trap Device

Gong, Ying, Master's thesis, University of Waterloo, ON, Canada. 91 pp, May 2008

The focus of this project was to develop needle trap devices (NTDs) with appropriate sorbents and employ them for air sampling in either diffusive or active sampling mode. For diffusive sampling, the NTD with sorbent Carboxen1000 was developed to monitor benzene, toluene, ethylbenzene, and o-xylene (BTEX) in air, coupled with GC-MS. Factors such as sorbent strength, response time, face velocity, temperature and pressure, relative humidity and sampling duration were investigated. Method validations were done in both lab and field. The results demonstrate that the NTD with Carboxen1000 is a successful diffusive sampler for monitoring time-weighted average concentrations of BTEX. For another application, the NTD with divinylbenzene (DVB) coupled with GC-MS by thermal desorption was developed for sampling and analysis of volatile thiols. The NTD with sorbent DVB is a successful active sampler for determine volatile thiols in food and air samples. Potential application of this device includes field sampling analysis.

<http://uwspace.uwaterloo.ca/handle/10012/3644>

Development of a gfp-Based Biosensor for Detecting the Bioavailability and Biodegradation of Polychlorinated Biphenyls (PCBs)

Liu, X., K.J. Germaine, D. Ryan, and D.N. Dowling, Inst. of Technology Carlow, Ireland. Journal of Environmental Engineering and Landscape Management, Vol 15 No 4, p 261-268, 2007

Two whole-cell biosensors were constructed to detect the in situ biodegradation of polychlorinated biphenyl by chromosomal insertion of a construct into *P. fluorescens*. In vitro tests showed that the expression of the Pm promoter depended on the growth phase of the biosensors and the concentration of chemical inducers, chlorinated benzoic acid derivatives. A linear relationship between the fluorescent intensity and the log₁₀ concentration of the inducer was observed. One biosensor (F113L::1180gfp) had the ability to degrade PCBs to relevant chloro-benzoic acid derivatives and to induce expression of Gfp. The second biosensor (F113gfp), which cannot degrade PCBs, shows fluorescence after induction by chloro-benzoic acid derivatives. With these two biosensors, PCB degradation could be detected in vitro and in soil; however, further studies will be needed to investigate the encapsulation of the biosensor in

an alginate matrix and its use to report on PCB degradation in real PCB-contaminated soil.
<http://www.jeelm.vgtu.lt/en/lt/3/NR/PUB/11699>

Development of a One-Step Strip for the Detection of Triazophos Residues in Environmental Samples

Gui, W.J., S.T. Wang, Y.R. Guo, and G.N. Zhu, Zhejiang Univ., Hangzhou, China.
Analytical Biochemistry, Vol 377 No 2, p 202-208, 15 June 2008

A one-step strip based on nanocolloidal-gold-labeled monoclonal antibodies was developed for detection of triazophos residue. The nanocolloidal gold, with an average particle diameter of 25 nm (G25), was labeled to an antitriazophos monoclonal antibody. This conjugate was dispensed on the conjugate pad of a porous glass fiber. Ovalbumin hapten and goat anti-mouse IgG were dispensed on the nitrocellulose membrane and served as the test line (T-line) and control line (C-line), respectively. After conditions optimization, the one-step strip was finally developed for the residue determination of triazophos. The limit of detection (LOD) of the strip was 4 ng/mL for standard. The detection was not affected by the pH of the liquid sample, but low total ion concentration induces illegible C-line and T-line. The LOD for spiked samples of soil and water was 5ng/mL at a run time of no more than 10 min.

Development of an Integrated Wireless Sensor Network Micro-Environmental Monitoring System

Cao, X., J. Chen (Zhejiang Univ., Hangzhou, PR China), Y. Zhang, and Y. Sun.
ISA Transactions, Vol 47 No 3, p 247-255, July 2008

The wireless sensor network (WSN) is increasingly popular in the field of micro-environmental monitoring, but most systems using WSN for environmental monitoring reported in the literature are developed for specific applications without functions for exploiting the user's data processing methods. This paper describes a new system designed to perform micro-environmental monitoring and take advantage of the WSN. Several strategies are proposed to guarantee the system capability in terms of extracting useful information and visualizing events to their authentic time. A web-based surveillance subsystem is presented for remote control and monitoring. The system is extensible for engineers to carry their own data analysis algorithms. Experimental results show the path reliability and real-time characteristics and display the feasibility and applicability of the developed system in practical deployment.

Direct, Continuous Monitoring of Air Pollution by Transgenic Sensor Mice Responsive to Halogenated and Polycyclic Aromatic Hydrocarbons

Kasai, A., N. Hiramatsu, K. Hayakawa, J. Yao, and M. Kitamura, Univ. of Yamanashi, Yamanashi, Japan.

Environmental Health Perspectives, Vol 116 No 3, p 349-354, Mar 2008

The aryl hydrocarbon receptor (AhR, also called the dioxin receptor) plays crucial roles in toxicologic responses of animals to environmental pollutants, especially to halogenated and polycyclic aromatic hydrocarbons. To achieve direct, continuous risk assessment of air pollution via biological systems, researchers generated transgenic sensor mice that produce secreted alkaline phosphatase (SEAP) under the control of AhR. Sensor mice were orally administered

2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), 3-methylcholanthrene (3MC), benzo[a]pyrene (B[a]P), or beta-naphthoflavone (BNF), and serum levels of SEAP were evaluated. To monitor air pollution, the mice were placed each day in an experimental room, and the activity of serum SEAP was evaluated for up to 4 days. Activation of AhR in individual organs was also examined by reverse transcription-polymerase chain reaction (RT-PCR) analysis of SEAP. In response to oral exposure to TCDD, sensor mice exhibited dramatic and sustained activation of AhR. The mice also responded sensitively to 3MC, B[a]P, and BNF. Activation of AhR was dose dependent, and the liver was identified as the main responding organ. After exposure to the contaminated air, the sensor mice consistently exhibited transient, reversible activation of AhR. RT-PCR analysis of SEAP revealed that activation of AhR occurred predominantly in the lung. The exposure of genetically engineered mammals shows potential for real risk assessment of halogenated and polycyclic aromatic hydrocarbons in the air.

Direct Measurement of Fugitive Emissions of Hydrocarbons from a Refinery
Chambers, A.K. and M. Stroscher (Alberta Research Council Inc., Edmonton, Alberta); T. Wootton, J. Moncrieff, and P. McCready (Spectrasyn Ltd., Hampshire, UK).
Journal of the Air & Waste Management Association, Vol 58 No 8, Aug 2008

Differential absorption light detection and ranging (DIAL) can measure concentration profiles of hydrocarbons in the atmosphere remotely up to several hundred meters from the instrument. When combined with wind speed and direction, downwind vertical DIAL scans can be used to calculate mass fluxes of the measured gas leaving a site. A mobile DIAL survey was completed at a Canadian refinery to quantify fugitive emissions of methane, C₂+ hydrocarbons, and benzene and to apportion the hydrocarbon emissions to the various areas of the refinery. The DIAL study measured 1,240 kg/hr C₂+ hydrocarbons, 300 kg/hr methane, and 5 kg/hr benzene in fugitive refinery emissions. Storage tanks accounted for over 50% of the total emissions of C₂+ hydrocarbons and benzene. The coker area and cooling towers also were significant sources. The C₂+ hydrocarbons emissions measured during the demonstration amounted to 0.17% of the mass of the refinery hydrocarbon throughput for that period. If the same loss were repeated throughout the year, the lost product would represent a value of US\$3.1 million/yr. The DIAL-measured hourly emissions of C₂+ hydrocarbons were 15 times higher than the emission factor estimates and gave new perspective on the refinery's main sources of emissions.

Direct Spectrophotometric Analysis of Cr(VI) Using a Liquid Waveguide Capillary Cell
Levitskaia, T.G., M.J. O'Hara, S.I. Sinkov, and O.B. Egorov, PNNL, Richland, WA.
Applied Spectroscopy, Vol 62 No 1, p 107-115, Jan 2008

Enhanced ultraviolet-visible (UV-vis) spectroscopy using a liquid waveguide capillary cell (LWCC) offers an easy-to-use and economical methodology for the determination of chromate anion CrO₄(2-) in Hanford natural waters without chemical pretreatment and generation of hazardous waste. Direct determination of CrO₄(2-) in actual surface water and groundwater samples despite the complexities of competing ions, dissolved organics, and other potential interfering agents was achieved by measuring the chromate optical absorbance at 372 nm. For a 100 cm path length LWCC, the detection limit for chromate was found to be as low as 0.073 ppb. A quantitative relationship between the intensity of the absorbance signal and water pH allowed for the straightforward calculation of total Cr(VI) content in natural water. The

described method is applicable for in-field monitoring of Cr(VI) in environmental water samples at trace levels.

A Directional Passive Air Sampler for Monitoring Polycyclic Aromatic Hydrocarbons (PAHs) in Air Mass

Tao, S., Y.N. Liu, C. Lang, W.T. Wang, H.S. Yuan, D.Y. Zhang, W.X. Qiu, J.M. Liu, Z.G. Liu, S.Z. Liu, R. Yi, M. Ji, and X.X. Liu, Peking Univ., Beijing, China.
Environmental Pollution, Vol 156 No 2, p 435-441, Nov 2008

A passive air sampler was developed for collecting polycyclic aromatic hydrocarbons (PAHs) in air mass from various directions. The airflow volume passing the sampler was linearly proportional to ambient wind speed and sensitive to wind direction, and the uptake rate for an individual PAH was a function of airflow velocity, temperature, and the octanol-air partitioning coefficient of the PAH. For all PAHs with more than two rings, the passive sampler operated in a linear uptake phase for three weeks. Different PAH concentrations were obtained in air masses from different directions in the field test.

Disposable Biosensor Based on Enzyme Immobilized on Au-Chitosan-Modified Indium Tin Oxide Electrode with Flow Injection Amperometric Analysis

Lin, J., W. Qu, and S. Zhang, Qingdao Univ. of Science and Technology, Qingdao, P.R. China.
Analytical Biochemistry, Vol 360 No 2, p 288-293, 15 Jan 2007

An indium tin oxide (ITO) electrode was used to fabricate a novel disposable biosensor combined with flow injection analysis for the rapid determination of hydrogen peroxide (H₂O₂). The biosensor was prepared by entrapping horseradish peroxidase (HRP) enzyme in a colloidal gold nanoparticle-modified chitosan membrane (Au-chitosan) to modify the ITO electrode. Under optimal conditions, H₂O₂ could be determined in the linear calibration range from 0.01 to 0.5 mM, with a correlation coefficient of 0.997 (n=8). The amperometric response of the biosensor showed no obvious decrease after continuous injection of the substrates 34 times into the flow cell. The prepared biosensor is economical and disposable due to the low-cost ITO film electrode obtained from industrial mass production, and exhibits good detection precision, acceptable accuracy, and storage stability for batch fabrication.

Drinking Water: The Need for Constant Innovation

Eawag: Swiss Federal Institute of Aquatic Science and Technology News Release, 12 Sep 2008

The safety of water supplies depends crucially on continuous monitoring; however, traditional methods for microbiological analysis of drinking water involve the growth of visible colonies of bacteria on nutrient plates. The plating method is time consuming and underestimates the number of microorganisms contained in water samples. Eawag has now developed an analytical method based on flow cytometry. This process, in which cells pass through a laser beam, has mainly been used to date in medicine (e.g., for blood cell counts). The process was adapted to permit reliable enumeration of bacterial cells. Rather than having to wait 18 to 24 hours, results are now available within 15 minutes. In close cooperation with Zurich Waterworks (WVZ), researchers demonstrated that the results stand up well in comparison with conventional methods, even providing a considerably more realistic picture due to a special labeling method

that also detects microorganisms that do not reproduce on nutrient media and therefore have been considered incorrectly to be inactive or dead. What makes the new method especially attractive--particularly for monitoring the microbiological safety of drinking water in developing countries--is the fact that by using specific antibodies, it is possible to screen samples for specific pathogens, which would facilitate a rapid response in the event of contamination.

http://www.eawag.ch/media/20080912/index_EN

Effect of Housing Geometry on the Performance of Chemcatcher(r) Passive Sampler for the Monitoring of Hydrophobic Organic Pollutants in Water

Lobpreis, T., B. Vrana (Water Research Inst., Bratislava, Slovakia), E. Dominiak, K. Dercova, G.A. Mills, and R. Greenwood.

Environmental Pollution, Vol 153 No 3, p 706-10, June 2008

An integrative passive sampler, the Chemcatcher(r), has been developed and calibrated for the measurement of time-weighted average concentrations of hydrophobic pollutants in water. Effects of physicochemical properties and environmental variables (water temperature and turbulence) on kinetic and thermodynamic parameters characterizing the exchange of analytes between the sampler and water have been published. In an investigation of the effect of modification in sampler housing geometry on these calibration parameters, the results obtained for PAHs show that reducing the depth of the cavity in the sampler body geometry increased the exchange kinetics about twofold, while having no effect on the correlation between the uptake and offload kinetics of analytes. The use of performance reference compounds thus avoids the need for extensive re-calibration when the sampler body geometry is modified.

Electrical Resistivity Imaging to Monitor a Simulated Leak from an Underground Storage Tank at a Radiological Waste Facility

Rucker, D., B. Cubbage, M. Levitt, and D. Glaser, hydroGEOPHYSICS, Tucson, AZ.

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 231-240, 2007

An electrical resistivity survey was performed during a simulated leak near an underground storage tank at DOE's Hanford facility. The resistivity data collection involved 8 surface arrays oriented along orthogonal lines and 42 steel-cased wells completed in the vadose zone in the S Tank Farm. A secondary resistivity-based continuous monitoring system hooked to a subset of 15 wells around the S-102 tank provided high resolution resistivity measurements during the simulated leak. Monitoring was performed in 3 phases to determine the effects of fluid migration: (1) pre-leak, to establish baseline conditions, (2) mid-leak, using the secondary resistivity-based continuous monitoring system, and (3) a post-leak survey conducted several weeks after the injection to determine the simulated leak's migration. The results of the S Tank Farm resistivity monitoring survey showed that resistivity data collected exclusively on the steel-cased wells compared favorably with data collected on the surface arrays over areas of limited infrastructural interferences. Given circumstances where infrastructure is pervasive and surface resistivity data are unreliable, it is likely that a monitoring system that relies solely on steel-cased wells would provide a favorable interpretation of leaking underground storage tanks.

An Electrochemical Sensor for Pesticide Assays Based on Carbon Nanotube-Enhanced Acetylcholinesterase Activity

Chen, H., X. Zuo, S. Su, Z. Tang, A. Wu, S. Song, D. Zhang, and C. Fan, Shanghai Jiao Tong Univ., Shanghai, China.

Analyst, Vol 133 No 9, p 1182-1186, Sep 2008

Multiwalled carbon nanotubes (MWNTs) loaded on glassy carbon (GC) electrodes significantly increase surface areas, facilitating the electrochemical polymerization of prussian blue (PB), a redox mediator for the electrochemical oxidation of the enzymatic product, thiocholine (TCh). MWNTs also enhance the enzymatic activity of AChE. The resulting electrochemical pesticide sensor exhibited rapid response and high sensitivity toward the detection of a series of pesticides. The sensor also was stable, reproducible, and selective enough for detection in real samples.

Emergency Preparedness

HazMat Magazine, Summer 2008

GE Security's "StreetLab Mobile" is an innovative, field-ready handheld device capable of detecting both chemical and biological agents. This portable instrument is capable of point-and-shoot operation and should be of interest to law enforcement, first responders, and HazMat teams. StreetLab Mobile can identify chemical and biological substances in one hand-held Raman instrument. Ergonomic and lightweight, yet rugged, the device reliably identifies liquids, powders, and solids in a single step without sample destruction or subjective interpretation. The device uses extended-range wireless technology to deliver results rapidly on site, enabling tactical decisions to be made more quickly. The unit can be decontaminated completely after use. The device has been ergonomically optimized for ease of use in Level A gear, and joystick controls enable one-handed operation. Operational battery life is 5 hours. Extensive and expandable libraries allow for a range of identification needs. Automatic calibration assures accuracy. The device can sample through glass, plastic, transparent, and even translucent materials. The point-and-shoot configuration allows for analysis in original sample containers, and an integrated sample vial holder allows for added sampling flexibility.

Enumeration of Aromatic Oxygenase Genes to Evaluate Biodegradation during Multi-Phase Extraction at a Gasoline-Contaminated Site

Baldwin, B.R. (Microbial Insights Inc., Rockford, TN), C.H. Nakatsu, J. Nebe, G.S. Wickham, C. Parks, and L. Nies.

Journal of Hazardous Materials, [e-pub ahead of print], 2008

Real-time PCR enumeration of aromatic oxygenase genes and PCR-DGGE profiles were used to elucidate the impact of air flow from operation of a multi-phase extraction (MPE) system on the aquifer microbial community structure and function at a gasoline-contaminated site. Prior to system activation, ring-hydroxylating toluene monooxygenase (RMO) and naphthalene dioxygenase (NAH) gene copies were on the order of 10(6) to 10(10)copies/L in groundwater samples obtained from BTEX-contaminated wells. Aromatic oxygenase genes were not detected in groundwater samples obtained during continuous MPE, indicating decreased populations of BTEX-utilizing bacteria. During periods of pulsed MPE, total aromatic oxygenase gene copies

were not significantly different than prior to system activation, but shifts in aromatic catabolic genotypes were noted. The consistent detection of RMO, NAH, and phenol hydroxylase (PHE), which catabolizes further oxidation of hydroxylated BTEX metabolites, indicated the potential for aerobic biodegradation of dissolved BTEX during pulsed MPE.

Enumeration of Aromatic Oxygenase Genes to Evaluate Monitored Natural Attenuation at Gasoline-Contaminated Sites

Baldwin, B.R., C.H. Nakatsu, and L. Nies, Purdue Univ., West Lafayette, IN.
Water Research, Vol 42 No 3, p 723-731, 2008

Monitoring groundwater BTEX concentrations is the typical method to assess monitored natural attenuation (MNA) and bioremediation as corrective actions at gasoline-contaminated sites. Conclusive demonstration of attenuation via biodegradation, however, relies on converging lines of chemical and biological evidence to support a decision. The authors used real-time PCR quantification of aromatic oxygenase genes to evaluate the feasibility of MNA at two gasoline-contaminated sites. Phenol hydroxylase, ring-hydroxylating toluene monooxygenase, naphthalene dioxygenase, toluene monooxygenase, toluene dioxygenase, and biphenyl dioxygenase genes were routinely detected in BTEX-impacted wells. Aromatic oxygenase genes were not detected in sentinel wells outside the plume, indicating that elevated levels of oxygenase genes corresponded to petroleum hydrocarbon contamination. Total aromatic oxygenase gene copy numbers detected in impacted wells correlated positively to total BTEX concentration. Mann-Kendall analysis of benzene concentrations was used to evaluate the status of the dissolved BTEX plume. The combination of trend analysis of contaminant concentrations with quantification of aromatic oxygenase genes was used to assess the feasibility of MNA as corrective measures at both sites.

Environmental Monitoring for Biological Threat Agents Using the Autonomous Pathogen Detection System with Multiplexed Polymerase Chain Reaction

Regan, J.F., A.J. Makarewicz, B.J. Hindson, T.R. Metz, D.M. Gutierrez, T.H. Corzett, D.R. Hadley, R.C. Mahnke, B.D. Henderer, J.W. Breneman 4th, T.H. Weisgraber, and J.M. Dzenitis.
Analytical Chemistry, Vol 80 No 19, p 7422-7429, 1 Oct 2008

A new operational civilian biodefense capability continuously monitors the air in high-risk locations for biological threat agents. This stand-alone instrument--the Autonomous Pathogen Detection System (APDS)--collects and selectively concentrates particles from the air into liquid samples and analyzes the samples using multiplexed PCR amplification coupled with microsphere array detection. Researchers evaluated the APDS instrument's response to *Bacillus anthracis* and *Yersinia pestis* in the lab by spiking the liquid sample stream with viable spores and cells, bead-beaten lysates, and purified DNA extracts. APDS results also were compared to a manual real-time PCR method. Field data acquired during 74 days of continuous operation at a mass-transit subway station indicate the specificity and reliability of the APDS. The U.S. Department of Homeland Security recently selected the APDS as the first autonomous detector component of their BioWatch antiterrorism program. This sophisticated field-deployed surveillance capability now generates actionable data in one-tenth the time required for manual filter collection and analysis.

Evaluating LNAPL Contamination Using GPR Signal Attenuation Analysis and Dielectric Property Measurements: Practical Implications for Hydrological Studies

Cassidy, N.J., Keele Univ., Staffordshire, UK.

Journal of Contaminant Hydrology, Vol 94 Nos 1-2, p 49-75, 30 Oct 2007

Ground-penetrating radar (GPR) is a popular non-invasive geophysical tool for subsurface investigation and characterization. Recent studies have shown that the spatial/temporal variation in GPR signal attenuation can provide important information on the electrical properties of subsurface materials that, in turn, can be used to assess the physical and hydrological nature of the pore fluids and associated contaminants. A high percentage of current GPR studies related to light nonaqueous-phase liquids (LNAPLs) have been focused solely on contaminant mapping, with little emphasis placed on characterizing the hydrological properties. By comparing lab-based, dielectric measurements of LNAPL-contaminated materials with the GPR signal attenuation observed in both contaminated and 'clean' areas of an LNAPL contaminated site, new insights have been gained into the nature of contaminant distribution/saturation and the likely signal attenuation mechanisms. The results show that despite some practical limitations of the analysis technique, meaningful hydrological interpretations can be obtained on contaminant properties, saturation index, and biodegradation processes. The author also reports on a generalized attenuation/saturation model that has been developed to describe the physical and attenuation enhancement characteristics of the LNAPL-contaminated areas.

Evaluation of a Dialysis Sampler's Integrity in a Cold Climate

Iwakun, O., K. Biggar, J. Armstrong, R. Donahue, and D. Sego.

Ground Water Monitoring & Remediation, Vol 28 No 1, p 50-56, 2008

To resolve issues from previous studies on sampler integrity, diffusion samplers made from regenerated cellulose dialysis membrane were deployed in monitoring wells at two upstream oil- and gas-contaminated sites. The average ambient temperature in the monitoring wells was 4 +/- 1 degrees C over the 6-month test period. Burst pressure and tensile strength tests were used to determine the integrity of the samplers at two field sites over time. The test results showed no adverse impacts on the samplers' integrity after 6 months. These promising results indicate the potential of diffusion samplers from regenerated cellulose dialysis membrane when used for long-term monitoring associated with natural attenuation assessment under the conditions tested.

Evaluation of Alternative Approaches for Screening Contaminated Sediments and Soils for Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

Schrock, M. and A. Dindal (Battelle Memorial Inst.); S. Billets (U.S. EPA).

Journal of Environmental Management, [e-pub ahead of print], 2008

This paper presents a comparison of the results obtained from laboratory-based alternative approaches for screening sediment and soil samples for dioxin toxicity equivalents (TEQ(D/F)) to results obtained using traditional high resolution mass spectrometry (HRMS). The laboratory-based approaches included modifying the traditional HRMS analysis to make it more cost-effective (alternate 1613B), analyzing extracts that had been prepared for HRMS using low

resolution mass spectrometry, and determining total organic carbon (TOC) content as an indicator of PCDD/F content. These comparisons demonstrated that TEQ(D/F) values generated using toxicity equivalency factors proposed by the World Health Organization in 1998 applied to alternate 1613B and LRMS analyses have a strong linear correlation to the TEQ(D/F) values derived in the same fashion from traditional HRMS analysis. These results would have placed >90% of the samples within the same concentration intervals using ranges of <0.05, 0.05-0.50, 0.50-5, and >5ngTEQ/g. Natural log transformed data for TOC had significantly weaker correlation to TEQ(D/F), indicating that TOC is not a reliable indicator of TEQ(D/F) concentrations.

An Evaluation of Compound-Specific Isotope Analyses for Assessing the Biodegradation of MTBE at Port Hueneme, CA

Lesser, L.E., P.C. Johnson (Arizona State Univ., Tempe), R. Aravena, G.E. Spinnler, C.L. Bruce, and J.P. Salanitro.

Environmental Science & Technology, Vol 42 No 17, p 6637-6643, 1 Sep 2008

At Port Hueneme, CA, a dissolved-phase MTBE plume and associated engineered aerobic flow-through biobarrier have been well studied, leading to delineation of regions of known significant and limited bioattenuation. This well-characterized site allowed comparison of field-scale compound-specific isotope analysis (CSIA) results with a priori knowledge of aerobic MTBE biodegradation, leading to conclusions concerning the utility of CSIA as a diagnostic tool for other aerobic biodegradation sites. Overall, the results suggest that C-13 data alone may produce inconclusive results at sites where MTBE undergoes aerobic biodegradation, and that even with 2D CSIA, an increase in the confidence of data interpretation may be possible only with data sets larger than those typically collected in practice.

Evaluation of Liquid-Liquid Microextraction Using Polypropylene Microporous Membranes for the Determination of Organophosphorus Flame Retardants and Plasticizers in Water Samples

Garcia-Lopez, M., I. Rodriguez, and R. Cela, Univ. de Santiago de Compostela, Spain.

Analytical Chimica Acta, Vol 625 No 2, p 145-153, 12 Sep 2008

In an evaluation of the suitability of a microporous membrane liquid-liquid extraction (MMLLE) technique for the concentration of several organophosphate esters (OPs) in water samples, analytes first were extracted into a few microliters of an organic solvent, immobilized in the pores of a hollow polypropylene membrane, and then determined by gas chromatography with nitrogen/phosphorus detection (GC-NPD). Under final working conditions, polypropylene membranes 2 cm in length and containing about 7 uL octanol in the pores were dipped in a glass vial filled with 115 mL of water with 30% sodium chloride. Extractions were carried out for 12 h at room temperature under magnetic stirring. After that, analytes were recovered from the membrane with 0.2 mL of ethyl acetate. This extract was mixed with the internal standard (50 uL of a triphenyl phosphate solution in the same solvent) and finally reduced to ~50 uL. Overall enrichment factors for the optimized method ranged from 35 to 1400 times, and the achieved limits of quantification from 0.008 to 0.12 ng/mL, depending on the compound. Globally, the method showed an acceptable linearity and precision for all species, except for tris(2-ethylhexyl) phosphate (TEHP). The authors compare the performance of the MMLLE approach with that

reported for other solid- and liquid-phase microextraction techniques in the analysis of real water samples.

Evaluation of Non-Uniqueness in Contaminant Source Characterization Based on Sensors with Event Detection Methods

Kumar, J., E.M. Zechman, E.D. Brill, G. Mahinthakumar, S. Ranjithan, and J. Uber.
World Environmental and Water Resources Congress 2007: Restoring our Natural Habitat.
American Society of Civil Engineers, Reston, VA. ISBN: 0784409277, 2007

During a water distribution contamination event, sensors may be able to detect only the presence of a contaminant and not necessarily the complete concentration profile. In earlier work, the authors presented an evolutionary algorithm-based procedure for source characterization and for assessing non-uniqueness by generating a set of maximally different alternatives. In this paper, their procedure is extended to characterize a contaminant source and any non-uniqueness arising by using sensor information processed through different event detection methods.

http://www.secure-water.org/downloads/presentations/ewri/event_detection_Jitendra.pdf

Evaluation of the Aquatic Passive Sampler Chemcatcher for the Monitoring of Highly Hydrophobic Compounds In Water

de la Cal, A., M. Kuster, M.L. de Alda, E. Eljarrat, and D. Barcelo, IIQAB-CSIC, Barcelona, Spain.

Talanta, Vol 76 No 2, p 327-332, 15 July 2008

The Chemcatcher passive sampler was developed primarily for the detection and quantification of priority organic pollutants like PAHs in water. Developers now are focusing on highly hydrophobic compounds, such as the tetrabrominated diphenyl ether BDE-47, the hexabrominated diphenyl ether BDE-153, and DDT and its metabolites. The prototype sampling device consists basically of a receiving phase with high affinity for organic chemicals separated from the environment by a diffusion limiting membrane, both encased in a rigid PTFE body. C18 Empore disks were evaluated as receiving phase, obtaining a better accumulation when impregnated until saturation with n-octanol. Low density polyethylene was chosen as a diffusion membrane. Once optimized, accumulation was shown to be satisfactory in a period of 15 days. Preliminary uptake rates calculated from that accumulation indicate the utility of this device for the detection of DDXs and PBDEs, as calculated limits of detection are lower than the environmental concentrations usually reported.

Evaluation of the Chemcatcher(r) and DGT Passive Samplers for Monitoring Metals with Highly Fluctuating Water Concentrations

Allan, I.J. (Univ. of Portsmouth, UK), J. Knutsson, N. Guigues, G.A. Mills, A.M. Fouillac, and R. Greenwood.

Journal of Environmental Monitoring, Vol 9 No 7, p 672-681, July 2007

The diffusive gradient in thin film (DGT) and the Chemcatcher passive samplers can be used to provide time-weighted average (TWA) concentrations of labile metals, but the approaches to their calibration differ. DGT uses diffusion coefficients of metals in the hydrogel

layer, whereas Chemcatcher uses metal specific uptake rates, with both sets of values obtained under controlled laboratory conditions with constant aqueous metal concentrations. Because little is known of how these passive sampling devices respond to fluctuating concentrations, the authors evaluated the responsiveness of the two devices to rapidly changing concentrations of Cd, Cu, Ni, Pb, and Zn in natural fresh water, over a relatively short deployment time. Maximum metal concentrations in water varied between 70 and 140 ug/L. The TWA concentrations of Cd and Ni obtained with Chemcatcher and DGT agreed reasonably well with the total Cd and Ni concentrations measured in repeated unfiltered spot samples. For elements (Cu, Pb, Zn) that associate to a significant degree with suspended solids, colloids, or dissolved organic carbon, or form complexes with large organic ligands, optimum agreement was with the filtered or ultrafiltered fractions and with the predicted inorganic and inorganic/fulvic acid-associated fractions. While Chemcatcher-based TWA concentration ranges for Cu and Zn were in best agreement with the total filtered fraction, there was lack of agreement for Pb. The combined use of DGT devices with open pore (OP) and restricted pore (RP) gels allowed the labile fraction of metal associated with large organic ligands or DOC to be differentiated and quantified, since this is available to DGT OP but unable to diffuse into the DGT RP. This evaluation of the two sampling devices clearly demonstrated their ability to react reliably to transient peaks in concentration of metal pollutants in water and indicated where future efforts are needed to improve calibration data.

Evaluation of Two Commercial Field Test Kits Used for Screening of Groundwater for Arsenic in Northern India

Sankaramakrishnan, N., D. Chauhan, R.T. Nickson, R.M. Tripathi, and L. Iyengar, Indian Inst. of Technology, Kanpur, India.

Science of the Total Environment, Vol 401 No 1-3, p 162-167, 15 Aug 2008

In an evaluation of two relatively new arsenic field kits--the Wagtech Digital Arsenator (WFTK) and the Chem-In Corp field test kit (CFTK)--the kits were applied to 157 arsenic-contaminated field samples and the results were compared with a laboratory-based colorimetric method (the silver diethyldithiocarbamate method). The concentration of arsenic in the 157 samples ranged from 0 to 468 ug/L. WFTK is seen to be suitable for measuring arsenic concentration <5 to 100 ug/L using the digital meter. CFTK was not able to detect As(V), and its usage is cautioned in areas where As(V) is known to occur in appreciable concentrations. The Pearson's correlation between each field kit and the silver diethyldithiocarbamate method was 0.87 for WFTK and 0.41 for CFTK in the concentration range used in this study. Spearman's rank correlation coefficients comparing the WFTK and CFTK to laboratory measurements in the concentration range of 0 to 100 ug/L were 0.95 ($p < 0.001$) and 0.64 ($p < 0.001$) respectively.

Evaluation of the Use of Diffusive Air Samplers for Determining Temporal and Spatial Variation of Volatile Organic Compounds in the Ambient Air of Urban Communities

Stock, T.H., M.T. Morandi, and M. Afshar (Univ. of Texas School of Public Health, Houston); K.C. Chung (U.S. EPA, Dallas, TX).

Journal of the Air & Waste Management Association, Vol 58 No 10, Oct 2008

A multi-phase study was conducted in the Houston-Galveston metropolitan area to evaluate the use of simple passive air samplers to determine temporal and spatial variability of

the ambient air concentrations of selected VOCs in urban areas. This paper reports on Phase 1 of the study: a field evaluation of 3M organic vapor monitors (OVMs) involving limited comparisons with commonly used active sampling methods, assessment of sampler precision, determination of optimal sampling duration, and investigation of the utility of a simple modification of the commercial sampler. The results indicate that the OVMs can be used successfully to monitor short-term (72-hr average) ambient air concentrations of multiple VOCs.

Evaluation of Using Caged Clams to Monitor Contaminated Groundwater Exposure in the Near-Shore Environment of the Hanford Site 300 Area

Larson, K.B., T.M. Poston, and B.L. Tiller, Pacific Northwest National Laboratory, Richland, WA. PNNL-17270, 46 pp, 2008

The Asiatic clam (*Corbicula fluminea*) has been identified as an indicator species for locating and monitoring contaminated groundwater in the Columbia River. Pacific Northwest National Laboratory conducted a field study to explore the use of caged Asiatic clams to monitor contaminated groundwater upwelling in the 300 Area near-shore environment and assess seasonal differences in uranium uptake in relation to seasonal flow regimes of the Columbia River. Additional objectives included examining the potential effects of uranium accumulation on growth, survival, and tissue condition of the clams. This report documents the field conditions and procedures, laboratory procedures, and statistical analyses used in collecting samples and processing the data. Detailed results are presented and illustrated, followed by a discussion comparing uranium concentrations in Asiatic clams collected at the 300 Area and describing the relationship between river discharge, groundwater indicators, and uranium in clams. Growth and survival, histology, and other sources of environmental variation also are discussed.

<http://www.pnl.gov/publications/abstracts.asp?report=233550>

Evaluation of Viking 573 GC/MS System and Chemical Warfare Agent (CWA) Detection

Austin, E. and K.T. Hoang.

ECBC-TR-593, NTIS: ADA477098, 23 pp, Dec 2007

The Mobile Laboratories & Kits (ML&K) Team, U.S. Army Edgewood Chemical Biological Center, was funded by the New York City Department of Environmental Protection (NYCDEP) to evaluate a portable Gas Chromatography/Mass Spectrometry (GC/MS) system that they routinely use in mobile laboratory applications. The NYCDEP provided a Bruker Viking 573 GC/MS system, which was verified according to manufacturer's recommendations. Members of the ML&K Team developed methods to evaluate the capabilities of the system against six chemical warfare agents (CWAs), including the Limit of Detection (LOD) and dynamic range for all six CWA compounds (GA, GB, GD, GF, HD, and VX) in organic solvent and soil matrices.

<http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA477098&Location=U2&doc=GetTRDoc.pdf>

Extraction and Determination of Organophosphorus Pesticides in Water Samples by a New Liquid Phase Microextraction-Gas Chromatography-Flame Photometric Detection
Khalili-Zanjani, M.R., Y. Yamini, N. Yazdanfar, and S. Shariati, Tarbiat Modares Univ., Tehran, Iran.

Analytical Chimica Acta, Vol 606 No 2, p 202-208, 14 Jan 2008

A fast, sensitive, and efficient liquid phase microextraction (LPME) method developed to determine trace concentrations of some organophosphorus pesticides in water samples combines liquid-phase microextraction with gas chromatographic (GC) analysis in a simple and inexpensive apparatus that consumes very little organic solvent. The method involves exposing a floated drop of an organic solvent on the surface of aqueous solution in a sealed vial. Under optimum extraction conditions, very low detection limits (0.01 to 0.04 ug/L) and good linearities ($0.9983 < r(2) < 0.9999$) were achieved. The LPME was performed for determination of organophosphorus pesticides in different types of natural water samples, and the results indicate that the newly proposed LPME method is a rapid, accurate, and effective sample preparation method that could be applied successfully for extraction and determination of organophosphorus pesticides in water samples.

Features of a Micro-Gas Chromatograph Equipped with Enrichment Device and Microchip Plasma Emission Detection (muPED) for Air Monitoring

Tienpont, B., F. David, W. Witdouck, D. Vermeersch, H. Stoeri, and P. Sandra, Research Inst. for Chromatography, Kortrijk, Belgium.

Lab on a Chip, Vol 8 No 11, p 1819-1828, Nov 2008

A field portable gas chromatograph (GC) was constructed allowing the enrichment of organic solutes from air samples on a miniaturized chemical trap and the subsequent GC analysis on a resistively heated capillary column. The heart of the system is an integrated chip-based plasma emission detector (muPED). As a non-selective detector, the sensitivity is similar to that of a flame ionization detector. The detector shows good selectivity for phosphorus, sulfur, and chlorine-containing compounds with relative selectivities of $\sim 5 \times 10(5)$ gP/gC, 50 gS/gC, and 10(2) gCl/gC. Under air monitoring conditions, the plasma chip can achieve better than 3,000 analyses.

Field Monitoring of Environmental Contaminant Lead around New Orleans by a Portable Instrument

Chou, J., A. Dantin, and L. Green (Southeastern Louisiana Univ., Hammond); Y. Duan (Los Alamos National Lab). American Chemical Society, Spring Meeting 2008, New Orleans, Louisiana. CHED #1092, poster presentation, 2008

Quantitative analysis of toxic metals commonly is done using inductively coupled plasma/mass spectroscopy or inductively coupled plasma/atomic emission spectroscopy and is performed in labs. A portable instrument--the Element Presence Detector (EPD 1.0)--is employed to monitor hazardous lead (Pb) on site around New Orleans. EPD is the world's first plasma source-based portable instrument that detects elements with continuous functions on line and in real time. The portable EPD 1.0 notifies workers of safety or quality concerns at the work site, enabling prompt corrective action. Potential applications include on-site monitoring of hazardous air particulates for manufacturing, in-line quality control for industrial processes, and

on-site element characterization, such as underground water source monitoring and environmental air quality monitoring.

Field Monitoring of Volatile Organic Compounds Using Passive Air Samplers in an Industrial City in Japan

Kume, K., T. Ohura, T. Amagai, and M. Fusaya, Univ. of Shizuoka, Japan.

Environmental Pollution, Vol 153 No 3, p 649-57, June 2008

Highly portable, sensitive, and selective passive air samplers were employed to investigate ambient VOC levels at multiple sampling sites in Fuji, an industrial city in Japan. The spatial distributions of 27 species of VOCs were determined in three campaigns of cold, warm, and mild seasons of 2004. In all campaigns, toluene was the most abundant VOC, followed by acetaldehyde and formaldehyde. The spatial distributions for certain VOCs showed characteristic patterns: high concentrations of benzene and formaldehyde typically were found along major roads, whereas high concentrations of toluene and PCE usually were found near factories. The spatial distribution of PCE observed was extremely consistent with the diffusion pattern calculated from Pollutant Release and Transfer Register data and meteorological data, indicating that passive air samplers are useful for determining the sources and distributions of ambient VOCs.

A Field Portable Microfluidic Perchlorate Sensor Using Contact Conductivity Detection

Henry, C. and B. Dressen (Colorado State Univ.); D. Cropek (U.S. Army Engineer Research and Development Center).

International Conference and Training -- Triad Investigations: New Approaches and Innovative Strategies, June 10-12, 2008, University of Massachusetts Amherst. Program Abstracts, p 33 (poster abstract), 2008

The development of perchlorate sensor technology is necessary to ensure the absence of perchlorate contamination, to detect perchlorate presence before migration off site, and to monitor remediation processes. Researchers are working to develop a microfluidic architecture and internal chemistry that can manipulate anions for spatial and temporal separations on a sensor chip with controlled movement toward sensitive on-chip detectors. Electrophoretic separation coupled with inchannel microwire conductivity detection has enabled sub-ppb determination of perchlorate in water. Analytical figures of merit are presented, including analysis of perchlorate in complex wastewater from an Army installation. The benefits of a field-portable perchlorate sensor are discussed.

Field Portable X-ray Fluorescence (FPXRF): A Rapid and Low Cost Alternative for Measuring Metals and Metalloids in Soils

Kilbride, C., J. Poole, T.R. Hutchings, O. Rodriguez-Walters, D. Sinnett, A. Brunt, and A.J. Moffat. CL:AIRE Research Bulletin 7 (RB-7), 4 pp, May 2008

The Field Portable X-Ray Fluorescence (FPXRF) analyzer is a portable analytical instrument for determining metal and metalloid concentrations in soils and other media (e.g., paint, alloys) and producing a display of the total metal and metalloid concentrations. The analyzer has real potential for determining soil metal and metalloid concentrations in the

laboratory or field quickly and effectively; producing a contaminant profile for a site; delineating contaminant hot spots; and evaluating the effects of remediation. The cost of sample analysis often compromises the extent of field sampling, which can increase the uncertainty regarding the estimation of contaminant extent and variability across a site. All sites do not need the same intensity and quality of data. The cost of getting it wrong may be low at a site in a low-risk setting but potentially high at a site in a high-risk setting. Assessment of the total metal and metalloid content of a soil is traditionally performed using an aqua regia or hydrofluoric acid (HF) digestion followed by inductively coupled plasma-optical emission spectrometer (ICP-OES) or atomic absorption spectrometer (AAS) analysis, which are relatively time-consuming and expensive methods of analysis. X-ray fluorescence (XRF) is more cost effective as it is carried out on a dried and ground sample and does not involve digestion of the soil material; however, this method still requires the removal of the sample to a laboratory. This bulletin provides guidance on the use of the FPXRF for the determination of metal and metalloid concentration in soils. The guidance is based upon the results of a laboratory experiment conducted to evaluate (1) the relationship between aqua regia extraction/ICP-OES and FPXRF analyzed metal levels and (2) the detection limits of FPXRF to test whether they are sufficient in the context of current UK guidance. The study showed that FPXRF is a powerful tool and useful in screening sites for major metal and metalloid contaminants, and the main advantages and limitations of the technology are summarized. A more complete account of the study can be found in Kilbride et al.(2006). Kilbride, C., J. Poole, and T.R. Hutchings. 2006. A comparison of Cu, Pb, As, Cd, Zn, Fe, Ni and Mn determined by acid extraction/ICP-OES and ex situ field portable X-ray fluorescence analysis. *Environmental Pollution* 143:16-23.

[http://www.forestry.gov.uk/pdf/CLAIRE_RB7.pdf/\\$FILE/CLAIRE_RB7.pdf](http://www.forestry.gov.uk/pdf/CLAIRE_RB7.pdf/$FILE/CLAIRE_RB7.pdf)

Field Testing a Flow-Through Sampler for Semivolatile Organic Compounds in Air

Xiao, H. (Univ. of Toronto Scarborough); H. Hung and T. Harner (Environment Canada); Y.D. Lei and F. Wania (Univ. of Toronto Scarborough).

Environmental Science & Technology, Vol 42 No 8, p 2970-2975, 15 Apr 2008

A flow-through sampler (FTS) can collect samples from large volumes of air by turning into the wind and having the wind blow through a porous sampling medium. To test its performance under field conditions, a FTS and a traditional pumped high volume air sampler, both using polyurethane foam (PUF) as sampling medium, were co-deployed from August 2006 to June 2007. Quantitative relationships between the wind speed outside the sampler and after passage through the PUF were established to allow estimation of sampling volumes under conditions of low and high wind speed. PCBs and PAHs were quantified in the samples taken by both air samplers. Separate analysis of 7 PUF disks arranged sequentially within the FTS confirms that even relatively volatile semivolatile organic compounds do not experience serious breakthrough. Air concentrations of PCBs and PAHs obtained with the FTS compare favorably with those obtained by averaging the concentrations of several 24-h active, high-volume samples taken during the same time period.

Field Testing of Equilibrium Passive Samplers to Determine Freely Dissolved Native Polycyclic Aromatic Hydrocarbon Concentrations

Cornelissen, G., A. Pettersen, D. Broman, P. Mayer, and G.D. Breedveld.

Environmental Toxicology and Chemistry, Vol 27 No 3, p 499-508, Mar 2008

In a study of native polycyclic aromatic hydrocarbons (PAHs) in Oslo Harbor, Norway, two different passive sampler materials, polyoxymethylene (POM, 55 μm thickness [POM-55] and 500 μm [POM-500]) and polydimethylsiloxane (PDMS, 200 μm thickness) were used to determine freely dissolved aqueous concentrations (CW/free) in sediment pore water (CPW/free) in the laboratory. Subsequently, the suitability of five passive samplers for determination of CW/free in overlying surface water was tested under field conditions. Both POM-55 and PDMS performed suitably in the laboratory for CPW/free. In the field, the shortest equilibrium times (approximately one month) were observed for POM-55 and PDMS (28 μm thickness) coatings on solid-phase microextraction fibers, with PDMS tubing a good alternative. Low-density polyethylene (100 μm thickness) and POM-500 did not reach equilibrium within 119 days in the field. At all four sampling stations, chemical activity ratios between pore water and overlying water were greater than one for all PAHs, indicating that the sediment was a PAH diffusion source.

FISH-RiboSyn: A Rapid Approach for Determining the Specific Growth Rate of a Distinct Microbial Population in a Mixed Culture

DuPont, S.J., M.R. Cutter, and P.G. Stroot.

World Environmental and Water Resources Congress 2007: Restoring our Natural Habitat.

American Society of Civil Engineers, Reston, VA. ISBN: 0784409277, 2007

Determining the specific growth rate of a distinct microbial population in a mixed culture or environmental sample has long been an elusive goal. FISH-RiboSyn is an in situ method that utilizes fluorescence in situ hybridization (FISH) with specific primers that target the interior region of both pre16S rRNA and mature 16S rRNA. FISH-RiboSyn provides an expedient method for determining the specific growth rate of a distinct microbial population in a mixed culture sample. Preliminary results show the linear increasing nature of fluorescence intensity as a function of chloramphenicol exposure time in pure cultures of *Acinetobacter calcoaceticus*.

Geochemical Evaluation of Metals in Groundwater at Long-Term Monitoring Sites and Active Remediation Sites

Thorbjornsen, K. and J. Myers, Shaw Environmental.

Remediation Journal, Vol 18 No 2, p 99-114, 2008

Long-term monitoring (LTM) programs can include metals as chemicals of concern, although they may not be site-related contaminants and their detected concentrations may be natural. At other sites, active remediation of organic contaminants in groundwater can alter local geochemical conditions that affect metal concentrations. Metals should be considered carefully at both types of sites, even where they are not primary contaminants of concern. Geochemical evaluation can be performed at LTM sites to determine if the monitored metals reflect naturally high background and therefore can be removed from the analytical program. Geochemical evaluation also can be performed pre- and post-treatment at active remediation sites to document

the effects of organics remediation on metals and to identify the processes controlling metal concentrations. This paper presents examples from both types of sites.

Geophysical Monitoring of Hydrological and Biogeochemical Transformations Associated with Cr(VI) Bioremediation

Hubbard, S., K.H. Williams, M.E. Conrad, B. Faybishenko, J. Peterson, and J. Chen (LBNL); P.E. Long (PNNL); T.C. Hazen (LBNL).

Lawrence Berkeley National Laboratory, Berkeley, CA

Environmental Science & Technology, Vol 42 No 10, p 3757-3765, 2008

The authors explored the use of geophysical approaches for monitoring the spatiotemporal distribution of hydrological and biogeochemical transformations associated with a Cr(VI) bioremediation experiment first by integrating hydrological wellbore and geophysical tomographic data sets to estimate hydrological zonation at the study site. Using results from laboratory biogeophysical experiments and constraints provided by field geochemical data sets, they then interpreted time-lapse seismic and radar tomographic data sets, collected during 13 acquisition campaigns over a 3-yr experimental period, in terms of hydrological and biogeochemical transformations. The geophysical monitoring data sets were used to infer the spatial distribution of injected electron donor, the evolution of gas bubbles, variations in total dissolved solids (nitrate and sulfate) as a function of pumping activity, the formation of precipitates and dissolution of calcites, and concomitant changes in porosity. The integrated interpretation illustrates how geophysical techniques have the potential to provide information about coupled hydrobiogeochemical responses to remedial treatments in high spatial resolution and in a minimally invasive manner.

<http://esd.lbl.gov/susanhubbard/pubs/es071702s.pdf>

A Green Flow-Based Procedure for Fluorimetric Determination of Acid-Dissociable Cyanide in Natural Waters Exploiting Multicommutation

Infante, C.M., J.C. Masini, and F.R. Rocha, Univ. de Sao Paulo, SP, Brazil.

Analytical and Bioanalytical Chemistry, Vol 391No 8, p 2931-2936, Aug 2008

A flow system designed with solenoid valves is proposed for determination of weak acid dissociable (WAD) cyanide, based on the reaction with o-phthalaldehyde (OPA) and glycine yielding a highly fluorescent isoindole derivative. The proposed procedure minimizes the main drawbacks (i.e., use of toxic reagents, high reagent consumption and waste generation, low sampling rate, and poor sensitivity) related to the reference batch procedure, based on reaction with barbituric acid and pyridine followed by spectrophotometric detection. Retention of the sample zone was exploited to increase the conversion rate of the analyte with minimized sample dispersion. Linear response was observed for cyanide concentrations in the range 1 to 200 ug/L, with a detection limit of 0.5 ug/L. The sampling rate and coefficient of variation were estimated as 22 measurements per hour and 1.4%, respectively. The results of determination of WAD cyanide in natural water samples agreed with those achieved by the batch reference procedure at the 95% confidence level.

Groundwater Plume, Source and Risk Identification Using Passive Soil Gas
Odencrantz, J.E. and H. O'Neill, Beacon Environmental Services, Bel Air, MD.

Proceedings of the Sixth International Battelle Conference: Remediation of Chlorinated and Recalcitrant Compounds, May 19-22, 2008, Monterey, California. Battelle Press, 5 pp, 2008

The results from 60 passive soil gas (PSG) samplers placed at a grain silo and mixed-use industrial facility with a known chlorinated solvent release expedited a rapid site investigation schedule. The samplers were used to determine potential sources, plume extent, and vapor risks in areas beyond the previous discrete soil sampling and permanent groundwater monitoring well network. PSG testing involves the installation of sorbents in a one-inch diameter hole, three feet deep, in which the samplers are placed at a depth of ~6 inches. The samplers were installed in grid pattern at a spacing of 25 to 50 feet at the site and across the street. The depth to groundwater was approximately 10 to 12 feet below grade. The installation of numerous monitoring wells in areas where TCE and PCE were discovered using the PSG samplers revealed two separate sources and groundwater plumes at the site, which became co-mingled downgradient. The PSG investigation was completed from start to finish in a two-week period of time. This paper focuses on the importance of PSG sampling for source identification, groundwater investigation, and compliance with regulatory directives for the assessment of the vapor intrusion pathway.

http://www.beacon-usa.com/pdf/Groundwater_and_PSG_Correlation.pdf

Improved Derivatisation Methods for the Determination of Free Cyanide and Cyanate in Mine Effluent

Zvinowanda, C.M., J.O. Okonkwo, and R.C. Gurira, Tshwane Univ. of Technology, Arcadia, Pretoria, South Africa.

Journal of Hazardous Materials, Vol 158 No 1, p 196-201, 1 Oct 2008

Cyanide speciation products, free cyanide (CN(-)), and cyanate (CNO(-)) were determined by highly sensitive derivatization methods followed by spectrometric analysis. Spectral scans were carried out for pure and environmental sample derivatives to evaluate interfering species. A linear range from 0.01 to 80.0 mg/L was determined for CN(-). The linear range was between 0.02 and 80.0 mg/L for CNO(-). The detection limits were 0.05 and 0.20 mg/L for CN(-) and CNO(-), respectively, which agree with those reported in literature. The concentration ranges of the speciation products in environmental samples were 0.70-52.0 mg/L and 0.50-76.0 mg/L for CN(-) and CNO(-), respectively. These values were well above their acute toxicity levels. Increase in cyanate levels in the effluent with time was clearly observed while the concentration of cyanide decreased. This was attributed to the oxidation of CN(-) to CNO(-).

An In Situ Device to Measure Oxygen in the Vadose Zone and in Ground Water: Laboratory Testing and Field Evaluation

Patterson, B.M. and G.B. Davis.

Ground Water Monitoring & Remediation, Vol 28 No 2, p 68-74, 2008

Determination of oxygen levels in the subsurface is important to the development and monitoring of a remedy involving aerobic bioremediation. Traditional methods of determining oxygen concentrations in soil gas and ground water are labor intensive and not easily automated

for semi-continuous monitoring. To remedy this need, a device incorporating an oxygen gas sensor within a silicone diffusion cell has been developed. This device, referred to as an oxygen probe, was designed to monitor in situ oxygen concentrations semi-continuously in gaseous and aqueous environments. The authors describe the results of laboratory tests and long-term field evaluations of these oxygen probes to demonstrate their reliability and usefulness.

<http://www3.interscience.wiley.com/cgi-bin/fulltext/120088160/PDFSTART>

Instantaneous Spectral Analysis: Time-Frequency Mapping via Wavelet Matching with Application to 3D GPR Contaminated Site Characterization

Bradford, J.H. (Boise State Univ., Boise, ID); Y. Wu (Anadarko, Inc., Houston, TX).

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 1260-1269, 2007 [A version of this paper was also published in The Leading Edge 26(8):1018-1023(2007)]

Time-frequency analysis, or spectral decomposition, can differentiate small-scale features associated with hydrocarbon reservoirs in seismic reflection data. Similar reflectivity anomalies are sometimes induced in ground-penetrating radar (GPR) data by electric property variations caused by groundwater contaminants that often are below the conventional resolution of the signal. Isolating and mapping discrete components of the time-frequency spectrum using spectral decomposition can highlight details of a contaminant distribution. The windowed Fourier transform was an early approach to spectral decomposition, but wavelet-based approaches have shown superior time-localization properties. The authors discuss the wavelet-matching spectral decomposition algorithm they developed at the Houston Advanced Research Center in the mid 1990s. In a 3-D GPR dataset acquired at the former Wurtsmith AFB, MI, the time-frequency attributes image details of a hydrocarbon plume not resolved by conventional instantaneous attributes or GPR AVO attributes.

<http://truman.seg.org/TLEreview/August/Bradford.pdf>

Integrated Approach to PCE-Impacted Site Characterization, Site Management, and Enhanced Bioremediation

Davis, G., B.R. Baldwin, A.D. Peacock, D. Ogles, G.M. White, S.L. Boyle, E. Raes, S.S. Koenigsberg, and K.L. Sublette.

Remediation Journal, Vol 18 No 4, p 5-17, 2008

Bio-Trap(r) samplers and quantitative polymerase chain reaction (qPCR) enumeration of *Dehalococcoides* spp. were used for a site contaminated with PCE and its breakdown products to evaluate three remedial options: monitored natural attenuation, biostimulation with HRC(r), and biostimulation with HRC-S(r). *Dehalococcoides* populations in HRC-S-amended traps deployed in impacted wells were on the order of 10³ to 10⁴ cells/bead but were below detection limits in most unamended and HRC-amended traps. The in situ Bio-Trap study identified biostimulation with HRC-S as the recommended approach, which was evaluated further with a pilot study. After the pilot HRC-S injection, *Dehalococcoides* populations increased to 10⁶ to 10⁷ cells/bead, and concentrations of cis-DCE and vinyl chloride decreased with concurrent ethene production. Based on the study results, a full-scale HRC-S injection was designed and implemented at the

site. Full-scale HRC-S injection promoted growth of *Dehalococcoides* spp. and stimulated reductive dechlorination of the daughter products cis-DCE and vinyl chloride.

Integrated Monitoring and Assessment of Soil Restoration Treatments in the Lake Tahoe Basin
Grismer, M.E. (Univ. of California, Davis); C. Schnurrenberger, R. Arst, and M.P. Hogan
(Integrated Environmental Restoration Services, Tahoe City, CA).

Environmental Monitoring and Assessment, [e-pub ahead of print] 2008

Revegetation and soil restoration efforts, often associated with erosion control measures on disturbed soils, are rarely monitored or otherwise evaluated in terms of improved hydrologic or ecologic function and longer-term sustainability. Erosion control measures can under-perform or simply fail after a few years. This paper outlines a comprehensive, integrated, field-based evaluation and assessment of the hydrologic function associated with soil restoration methods with the hypothesis that restoration of sustainable function will result in longer-term erosion control benefits than those currently achieved. The monitoring approach includes cover-point and ocular assessments of plant cover, species type, and diversity; soil sampling for nutrient status; rainfall simulation measurement of infiltration and runoff rates; and cone penetrometer measurements of soil compaction and thickness of mulch layer depths. The results of multi-year hydrologic and vegetation monitoring at 10 sites and 120 plots are provided to illustrate the potential of the integrated monitoring program.

The Integration of Network-Based Models for Spill Response and Homeland Security
Amstutz, D.E., R. Bahadur, J.M. Pickus, M.C. Monteith, J.P. Johnson, C.J. Ziemniak, M. Chehata, M.E. Herrera, and W.B. Samuels.

American Journal of Environmental Sciences, Vol 4 No 6, p 544-550, 2008

The integration of three hydraulic geographic information system applications is presented that represents the water infrastructures (drinking water distribution systems, wastewater collection systems, and source water) of cities and urban areas in the United States. The integration of these applications has been developed for use in planning, response, training, and development of monitoring strategies to address potential deliberate or accidental toxic contamination events.

<http://www.scipub.org/fulltext/ajes/ajes46544-550.pdf>

Investigating the Interior of a Landfill Cell with Leachate Injection Using Electromagnetic Conductivity and Ground-penetrating Radar Surveys

Carpenter, P., S. Grellier, K. Reddy, R. Adib, C. Peters, and J. Gangathulasi.

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Philadelphia, Pennsylvania. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 212-222, 2008

Bioreactor landfills enhance waste degradation through recirculation of leachate inside the waste structure. At the Orchard Hills landfill near Rockford, IL, frequency-domain electromagnetic (EM) conductivity was measured along several profile lines before, during, and after leachate injection at a cell. Electrical resistivity tomography (ERT) measurements also were made before, during, and after leachate recirculation. One profile line was located above a

leachate recirculation line (LRL). The other profiles were perpendicular to LRLs, which varied in depth from 5 to 15 m below the EM lines. Electrical conductivity increased along some segments of an EM profile over the LRL during injection of 17.8 cu m of leachate. Conductivity values were ~15 mS/m higher than pre-injection values along some segments of this line when measured with a Geonics EM 34 at 10 and 20 m vertical dipole separations. These zones also correspond to zones of decreased resistivity in the corresponding ERT sections. Leachate injection appears to be non-uniform along the LRL, with larger volumes entering the refuse at the beginning and in the middle of the injection interval. EM and ERT values during a second experiment, in which a smaller leachate volume was injected, showed no change. Ground-penetrating radar profiles made with 25 and 50 MHz antennas showed a diffraction at the position of one of the LRLs (4 to 5 m depth) and a probable layer (possibly an intermediate clay cover) at 5 to 6 m depth, although a 100 MHz profile only showed the geomembrane at 2.5 m depth. <http://www.uic.edu/classes/cemm/cemmlab/SAGEEP-2008.pdf>

Leak Detection

HazMat Magazine, Summer 2008

FLIR Systems, Inc., a leader in infrared cameras, has announced the addition of the ThermoCAMAE GasFindIR HSX to its line of GasFindIR infrared cameras for the detection of volatile organic compounds (VOCs). GasFindIR has been used extensively in oil and gas, and petrochemical companies as a way to find gas leaks as part of predictive maintenance programs. The GasFindIR HSX delivers high-volume scanning to spot leaks quickly and easily in tank cars, pipelines, and facilities. The GasFindIR HSX adds six new scene integration modes (for a total of nine scene integrations modes), new battery and power features, better image resolution, and new productivity features. The new camera helps predictive maintenance organizations maximize safety and profitability by keeping close watch on methane and other VOC leaks in facilities and pipelines. High Sensitivity Mode image enhancement provides five times better sensitivity for gas detection. Normal Scene, Cold Scene, and Hot Scene can be selected at 60 Hz, 30 Hz, or 15 Hz to optimize for scene conditions. By changing frame acquisition rates, thermographers can fine-tune image performance in hot and cold environments to help find the smallest leaks. Also new to the line is a Lithium ION battery that lasts eight hours and is field replaceable. The camera also comes with a new AC Adapter for 110/220 VAC, 50/60 Hz power and 12-volt connectivity to a vehicle.

http://www.hazmatmag.com/Issues/ISarticle.asp?id=200583&story_id=211590113216&issue=06012008&PC=&RType=

Long-Term Ground Penetrating Radar Monitoring of a Small Volume DNAPL Release in a Natural Groundwater Flow Field

Hwang, Y.K., A.L. Endres, S.D. Piggott, and B.L. Parker, Univ. of Waterloo, Waterloo, ON. Journal of Contaminant Hydrology, Vol 97 No 1-2, p 1-12, 4 Apr 2008

A field experiment at Canadian Forces Base Borden by Brewster and Annan in the 1990s demonstrated the capability of ground penetrating radar (GPR) reflection profiling to detect and monitor the formation of DNAPL layers in the subsurface. Their experiment involved a large volume release (770 L) of PCE in a confined area. In a new study, the authors evaluated the ability of GPR profiling to detect and monitor much smaller volume releases (50 L) in a natural

groundwater flow regime. The conditions allowed geophysical monitoring of DNAPL mass loss over a 66-month period. Reflectivity variations on the GPR profiles were used to infer the presence and evolution of the solvent layers. During the 2-week period immediately after the release, GPR imaging indicated significant reflectivity increases due to solvent layer formation. These results demonstrated the capacity of GPR profiling for the detection and monitoring of lesser-volume DNAPL releases that are more representative of small-scale industrial spills. After 29 months, the GPR-imaged solvent layers decreased in both areal extent and reflectivity and disappeared almost entirely by the end of the 66 month. Long-term monitoring results show that GPR profiling is a promising non-invasive method for use at DNAPL-contaminated sites in sandy aquifers where temporal information about immiscible contaminant mass depletion due to either natural flow or remediation is needed; however, the results also indicate that the GPR signature of older DNAPL-impacted zones may not differ significantly from the uncontaminated background if mass reduction due to dissolution has occurred.

A Low-Tech, Low-Cost Passive Sampler for the Long-Term Monitoring of Phosphate Loads in Rivers and Streams

Mueller, B., R. Stierli, and R. Gaechter, Swiss Federal Inst. for Environmental Science and Technology, Eawag, Kastanienbaum, Switzerland.

Journal of Environmental Monitoring, Vol 10 No 7, p 817-820, July 2008

Accurate estimation of the annual dissolved reactive phosphorus (DRP) load in a river requires frequent sampling or even continuous monitoring, which is laborious and cost intensive. A new, robust, low-cost, low-tech device has been developed based on passive samplers (P-traps). The traps use Fe-(oxy)hydroxide coated quartz sand as an adsorbent enclosed in a vertical grid of individual cells separated from the river water by filter membranes. These traps are inexpensive, easy to handle, resistant to repeated desiccation and immersion, and exposable for several months. The devices permit estimation of discharge-dependent time-weighted average DRP concentrations and annual P loads of rivers characterized by highly variable DRP concentrations with a relative accuracy of +/- 3%.

Mapping the Extent and Activity of Tree Root Systems with Self Potential and Misse a la Masse

Kepic, A. (Curtin Univ., Perth, Australia); T. Campbell (Geoforce, Perth); C. Hinz (Univ. of Western Australia).

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Philadelphia, Pennsylvania. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 223-232, 2008

The study of tree root systems and their interaction with the hydrogeological environment is a difficult task. Tree root studies are important for assessing tree-root area of influence during phytoremediation of groundwater contaminants, revegetating mining areas, and combating soil erosion. Typical studies grow a specimen and then excavate the area, usually killing the specimen, which makes time-lapse studies difficult to perform. A novel modification of the misse-a-la-masse technique can be used to determine the extent of the active root zone around a tree in a non-invasive manner. The technique injects current into the trunk of the tree compares the potentials on the surface to that obtained with a stake set into the ground near the trunk. The hypothesis is that the current exits the sap system into the earth through those roots, exchanging

water and ions with the soil. Initial tests allowed identification of the extent and influence of a single tree within a group, a task normally impossible without extensive dye tracer and excavation studies.

Mass to Concentration Tie-In for Passive Soil Gas Surveys: Improved Technique for Source Area, Spatial Variability and Vapor Intrusion Assessment

Odenchantz, J.E. and H. O'Neill (Beacon Environmental Services, Inc.); P.C. Johnson (Arizona State Univ.).

Proceedings of the AW&MA Vapor Intrusion 2009 Conference, January 27-30, 2009, San Diego, California. AW&MA, 2009

The mass-to-concentration tie-in [MtoC Tie-In] correlates passive soil gas (PSG) data in mass to active soil gas data in concentration determined by EPA Method TO-17. Passive soil gas surveys consist of rapid deployment of hydrophobic sorbents (dozens to several hundred locations typically installed in one day) to a depth of 6 inches to 3 feet in a grid pattern with exposure in the field from three days to two weeks to target organic compounds. A power function is used on a compound-to-compound basis to correlate spatially varying mass (nanograms) from selected locations within a passive soil gas survey to concentration ($\mu\text{g}/\text{m}^3$) at those same locations. The correlation from selected PSG locations is applied to the remainder of the PSG grid. The MtoC Tie-In correlations provides added value to a PSG survey, with the PSG data then used to estimate risk throughout the limits of the investigation for quantitative assessment. The results from a site in Northern California show the MtoC Tie-In correlations for both benzene and total petroleum hydrocarbons (TPH). The correlations are applied on a compound-to-compound basis to the remaining locations in the PSG-grid to provide an estimate of concentration that can be used for comparison to risk/screening levels or fate and transport diagnostic tools (partitioning equations, solubility laws, etc.). An example of how the correlations are applied is presented in tabular form. The results from a chlorinated solvent survey show the MtoC Tie-In correlation from a site in Maryland for PCE with a near-perfect relationship between the PSG mass and the active soil gas concentration. The concentration estimated throughout a PSG grid enables a vast new realm of interpretive power at sites. Results from other sites also are discussed.

http://www.beacon-usa.com/pdf/Mass_to_Concentration_Tie-In.pdf

Measurement Capability of Field Portable Organic Vapor Monitoring Instruments under Different Experimental Conditions

Coffey, C.C., T.A. Pearce, R.B. Lawrence, J.B. Hudnall, J.E. Slaven, and S.B. Martin Jr., NIOSH, Morgantown, WV.

Journal of Occupational and Environmental Hygiene, Vol 6 No 1, p 1-8, Jan 2009

The performance of field portable direct-reading organic vapor monitors (DROVMs) was evaluated under a variety of experimental conditions. Four of the DROVMs had photoionization detectors (ppbRAE, IAQRAE, MultiRAE, and Century Toxic Vapor Analyzer), one had a flame ionization detector (Century Toxic Vapor Analyzer), and one was a single-beam infrared spectrophotometer (SapphIRe). Four of each DROVM (two Century Toxic Vapor Analyzers and SapphIRes) were tested. The DROVMs were evaluated at three temperatures (4, 21, and 38 degrees C), three relative humidities (30, 60, and 90%), and two hexane concentrations (5 ppm

and 100 ppm). To evaluate performance, the 4-hr time-weighted average readings from the DROVMs in a given trial were compared with the average of two charcoal tube concentrations using pairwise comparison. The ppbRAE group performed the best, with 40% of all readings meeting the comparison criterion, followed by the SapphIRE group at 39%. Among individual DROVMs, the best performer was a SapphIRE, with 57% of its readings meeting the criterion. The results indicated that the performance of some DROVMs may be affected by temperature, humidity, and/or concentration. The ppbRAE group performed best at 21 degrees C, with the percentage of readings meeting the criterion increasing to 63%. At the 5 ppm concentration, 44% of the ppbRAE group readings met the criterion, but only 35% at 100 ppm. Although the results indicate that monitors can be used as survey tools, the inconsistent performance of these DROVMs may not support their use for determining compliance with occupational exposure limits.

Microbial Analysis of Soil and Groundwater from a Gasworks Site and Comparison with a Sequenced Biological Reactive Barrier Remediation Process

Ferguson, A.S. (Queen's University of Belfast, UK); W.E. Huang; K.A. Lawson; R. Doherty; O. Gibert; K.W. Dickson; A.S. Whiteley; L.A. Kulakov; I.P. Thompson; R.M. Kalin; M.J. Larkin. *Journal of Applied Microbiology*, Vol 102 No 5, p 1227-1238, 2007

The authors investigated the distribution of a polymicrobial community of biodegradative bacteria in soil and ground water at a former manufactured gas plant (MGP) site, as well as in a sequential reactive barrier (SEREBAR) bioremediation process implemented to bioremediate polycyclic aromatic hydrocarbons in the ground water. The investigators applied culture-dependent and culture-independent analyses using denaturing gradient gel electrophoresis and polymerase chain reaction for the detection of 16S ribosomal RNA gene and naphthalene dioxygenase genes of samples from across the site and from the SEREBAR process. Naphthalene in the ground water was degraded effectively early in the process, with microbiological analysis indicating a dominant role for *Pseudomonas* and *Comamonas* in its degradation. Comparisons made between areas contaminated with PAHs and those not contaminated revealed differences in the microbial community profile, indicating that noncultured bacteria were dominant in mediating naphthalene removal. This work emphasizes the importance of using both traditional and molecular-based tools to determine the microbial ecology of contaminated sites and highlights the role of noncultured bacteria in bioremediation.

Mimicking Body Biosensors: Artificial Antibodies Could Be Used in Cheap, Field-Ready Toxin Sensors

Bourzac, Katherine.

MIT Technology Review, Nov/Dec 2008

Antibodies are natural proteins that are widely used in diagnostic tests for cancer and other diseases because they recognize and bind so efficiently to disease markers, which include bacterial and viral proteins and protein fragments. Protein antibodies are expensive to synthesize in the lab, however, and last only a few months. Biochemists now have developed a method to make artificial antibodies that may be just as effective as the real thing. Researchers have been working on synthetic antibodies for about 20 years. Kenneth Shea, a professor of chemistry at the University of California, Irvine, has led the development of the new method. To make the

new and improved artificial antibodies, Shea and his collaborators at the Tokyo Institute of Technology refined a technique called molecular imprinting. This technique involves taking a target molecule and placing it in a solution containing the building blocks of a polymer antibody. The polymer then grows around its target, conforming to its shape; once it's done, the target molecule is rinsed away. When the artificial antibody next meets the target molecule, they fit together like a key in a lock. Klaus Mosbach, founder of the Center for Molecular Imprinting at the Center for Chemistry and Chemical Engineering, in Lund, Sweden, pioneered the technique. <http://www.technologyreview.com/biomedicine/21603/>

Monitoring and Assessment of Toxic Metals in Gulf War Oil Spill Contaminated Soil Using Laser-Induced Breakdown Spectroscopy

Hussain, T. and M.A. Gondal, National Univ. of Sciences & Technology, Rawalpindi, Pakistan. Environmental Monitoring and Assessment, Vol 136 Nos 1-3, p 391-399, Jan 2008

Laser-induced breakdown spectroscopy (LIBS) was applied for the detection of toxic metals in soil contaminated by an oil spill. Aluminum, magnesium, calcium, chromium, titanium, strontium, iron, barium, sodium, potassium, zirconium, and vanadium were detected in the contaminated soil. The LIBS system was calibrated using standard samples containing these trace elements, and the results obtained with LIBS were compared with the results obtained using inductively coupled plasma emission spectroscopy.

Monitoring of a Large-Scale Phytoremediation Site: Over Eight Years of Data

Negri, M.C., J. Quinn, G. Gopalakrishnan, L. Moos, R. Piorkowski, E. Gatliff, and N. Golchert. Abstracts: Fourth International Phytotechnologies Conference, 24-26 September 2007, Denver, Colorado: Abstracts, p 50, 2007

The phytoremediation site at Argonne National Laboratory in northeastern Illinois comprises over 800 trees. The plant system is designed for a multifaceted phytoremediation approach to dealing with volatile organic compounds (VOCs) and tritium in soil and ground water, including transpiration of contaminants, in situ breakdown in plant tissues and in the rhizosphere, and hydraulic containment. Hybrid willows and poplars comprise the remediation system, with willows in the source area and deep-rooted poplars (TreeWell(tm)) installed to capture the downgradient plume at 26 to 30 ft below ground surface (bgs). The authors discuss the integrated results of all monitoring activities conducted from 1999 to date and provide an assessment of technology performance and lessons learned. Monitoring data have been collected in the form of transpiration, leaf and branch contaminant concentrations, trunk core samples, continuous water levels, ground-water contaminant concentrations, tree growth (height and trunk diameter), weather parameters, soil and root studies, and other targeted studies. Methods for sample collection and laboratory analyses were developed to address project needs. While VOCs were found in the willows growing in the source area as early as two months from planting, their concentration and spatial distribution in the plants has followed different patterns as the trees grew and reached their mature size. Tritium also has been found consistently in tree transpiration in areas of trace ground-water concentrations, serving both as a tracer of rooting depth and a performance indicator parameter. Roots were found in the hydraulic control planting as deep as the capillary fringe, approximately 22 ft bgs in the glacial subsoil. As the plantation approaches maturity, synthesis of the monitoring data is indicating in-plant degradation processes,

contaminant mass uptake and removal rates, the effect of existing site infrastructure, and the anticipated overall efficiency of the project.

Multilevel Samplers as Microcosms to Assess Microbial Response to Biostimulation

Baldwin, B.R., A.D. Peacock, M.M. Park, D. Ogles, J.D. Istok, J.P. McKinley, C.T. Resch, and D.C. White.

Ground Water, Vol 46 No 2, p 295-304, 2008

Passive multilevel samplers (MLSs) containing a solid matrix for microbial colonization were deployed in a study of a push/pull biostimulation experiment designed to promote biological reduction of uranium (as U(VI)) and technetium (as Tc(VII)). MLSs were positioned at 24 elevations in the injection well and two downgradient wells to investigate the spatial variability in microbial community composition and growth before and after biostimulation. The microbial community--bacteria, nitrate-reducing bacteria, delta-proteobacteria, *Geobacter* sp., and methanogens--was characterized by real-time, quantitative polymerase chain reaction (Q-PCR). Pretest cell densities were low overall but varied substantially in the significantly greater bacterial populations detected at circumneutral pH, suggesting carbon substrate and low pH limitations of microbial activity. Although pretest cell densities were low, denitrifying bacteria dominated the microbial community. Biostimulation with an ethanol-amended ground water resulted in concurrent nitrate and Tc(VII) reduction, followed by U(VI) reduction. Q-PCR analysis of MLS revealed significant (1 to 2 orders of magnitude) increases in cell densities of bacteria, denitrifiers, delta-proteobacteria, *Geobacter* sp., and methanogens in response to biostimulation. Traditionally, characterization of sediment samples has been used to investigate the microbial community response to biostimulation; however, collection of sediment samples is expensive. Results show that push/pull tests with passive MLS provide an inexpensive approach to determine the effect of biostimulation on contaminant concentrations, geochemical conditions, and microbial community composition and function.

Multi-Residue Analytical Method for the Determination of Emerging Pollutants in Water by Solid-Phase Extraction and Liquid Chromatography-Tandem Mass Spectrometry

Rodil, R., J.B. Quintana, P. Lopez-Mahia, S. Muniategui-Lorenzo, and D. Prada-Rodriguez, Univ. of A Coruna, Spain.

Journal of Chromatography A, 2008

This paper describes the development and validation of a method for the simultaneous determination of 53 multi-class emerging organic pollutants in water samples using solid-phase extraction (SPE) followed by liquid chromatography-tandem mass spectrometry (LC-MS/MS), using electrospray ionization (ESI) in both positive and negative modes. Target compounds include acidic herbicides, UV filters, insect repellents, organophosphorous flame retardants, a bactericide, pharmaceuticals, and metabolites. A single SPE consisting on the loading of 200-500 mL of sample adjusted to pH 7 on Oasis HLB 200 mg cartridges and elution with methanol permitted good recoveries--higher than 60% for tap, surface, and wastewater in most cases. The precision of the method was below 15% for all compounds and all tested matrices. The method was applied to the determination of target analytes in tap, surface, and waste water. Among the tested emerging pollutants, 31 were found in wastewater in concentrations reaching up to 10

ug/L in the case of ibuprofen. Thirteen species were detected in tap water with concentrations up to 0.13 ug/L for tri(chloropropyl) phosphate.

A New Generation of Cyanide Ion-Selective Membranes for Flow Injection Application: Part III. A Simple Approach to the Determination of Toxic Metal-Cyanide Complexes without Preliminary Separation

Surleva, A.R. and M.T. Neshkova, Univ. of Chemical Technology and Metallurgy, Sofia, Bulgaria.

Talanta, Vol 76 No 4, p 914-921, 15 Aug 2008

A new flow injection approach to total weak acid-dissociable (WAD) metal-cyanide complexes eliminates the need of a separation step (such as gas diffusion or pervaporation) prior to detection. The new methodology is based on the highly selective flow-injection potentiometric detection (FIPD) system that makes use of thin-layer electroplated silver chalcogenide ion-selective membranes of non-trivial composition and surface morphology: $\text{Ag}(2+\delta)\text{Se}(1-x)\text{Te}(x)$ and $\text{Ag}(2+\delta)\text{Se}$. An inherent feature of the FIP-detectors is their specific response to the sum of simple $\text{CN}(-)+\text{Zn}(\text{CN})_4(2-)+\text{Cd}(\text{CN})_4(2-)$. Ligand exchange (LE) and a newly developed electrochemical pre-treatment procedure for release of the bound cyanide were used for total WAD cyanide determination. The LE pre-treatment ensures complete recovery only when the sample does not contain $\text{Hg}(\text{CN})_4(2-)$. This limitation is overcome by implementing electrochemical pre-treatment that liberates completely the bound WAD cyanide through cathodic reduction of the complexed metal ions. A complete recovery of toxic WAD cyanide is achieved in the concentration range from 156 ug/L up to 13 mg/L. The authors propose a three-step protocol for individual and group WAD cyanide speciation. The speciation protocol comprises three successive measurements of non-treated, LE-exchange pre-treated, and electrochemically pre-treated sample. In the presence of all WAD complexes, this procedure provides complete recovery of the total bound cyanide along with its quantitative differentiation into the following groups: (1) $\text{Hg}(\text{CN})_4(2-)$; (2) $\text{CN}(-)+\text{Cd}(\text{CN})_4(2-)+\text{Zn}(\text{CN})_4(2-)$; (3) $\text{Cu}(\text{CN})_4(3-)+\text{Ni}(\text{CN})_4(2-)+\text{Ag}(\text{CN})_2(-)$. A 100-fold excess of $\text{CO}_3(2-)$, $\text{SCN}(-)$, $\text{NH}_4(+)$, $\text{SO}_4(2-)$, and $\text{Cl}(-)$ does not interfere. The proposed approach offers a step ahead to meeting the ever increasing demand for cyanide species-specific methods. The simplicity of the approach makes the procedure a good candidate for use in portable devices for cyanide monitoring in the field.

A New Monitoring PAM Fluorometer (MONI-PAM) to Study the Short- and Long-Term Acclimation of Photosystem II In Field Conditions

Porcar-Castell, A., E. Pfuendel, J.F. Korhonen, and E. Juurola, Univ. of Helsinki, Finland. Photosynthesis Research, Vol 96 No 2, p 173-179, 2008

Photosystem II is the energy from light absorbed by chlorophyll and transferred to electrons; these high-energy electrons are passed on to the electron transport chain. Fluorescence occurs when electrons excited by the absorption of light energy (i.e., electromagnetic radiation) fall back down to their unexcited state. A new pulsed-amplitude modulation (PAM) fluorometer (MONI-PAM) is intended for short- and long-term field monitoring of the acclimation of photosystem II (PSII). The instrument measures chlorophyll fluorescence, photosynthetic photon flux density, and temperature in the field, and monitors exactly the same leaf area over prolonged

periods of time, facilitating the estimation of both rapidly reversible and sustained non-photochemical quenching. The MONI-PAM performance was evaluated under natural conditions in a Scots pine canopy during spring recovery of photosynthesis. The instrument provides a new tool to study in detail the acclimation of PSII to the environment under natural field conditions. The PAM tools can be used to assess the effects of contaminants on photosynthetic electron transport.

New Sandia Sensor to Have Applications in Homeland Defense, Safeguarding Warfighters, Clinical Diagnostics: Sensor Will Be Capable of Simultaneously Detecting Thousands of Proteins, DNA, Whole Cells, and Pathogens

Sandia National Laboratory News Release, 30 April 2007

A Sandia National Laboratories research team is developing a new type of electrochemical sensor that uses a unique surface chemistry to detect thousands of differing biomolecules reliably and accurately on a single platform. The new sensor allows multiple characteristics of several bioagent targets to be tested on a single chip. For example, instead of using only an antibody that binds to the surface of an anthrax spore, the new sensor could test for several DNA sequences and internal and external proteins unique to anthrax. This provides numerous positive readings for the target agent or agents, significantly increasing confidence in the sensor results. By integrating antibodies, DNA, and other biomolecules on a single device, the number of lab instruments, volume of reagents required, time for analysis, and the cost of performing effectively thousands of tests are all reduced. The platform, a microfabricated chip, is just one inch by one inch in size. Several technological advances in microfabrication processes have increased the numbers of electrodes that can be produced on a sensor platform. A major challenge is how to pattern different biomolecules onto closely spaced micrometer-sized electrodes. The research team believes the answer lies in the electrodeposition of aryl diazonium salts, which can be deposited selectively onto several types of substrates by controlling the charge of the substrate in the diazonium solution. Upon deposition, covalent bonds are formed with the substrate, producing a highly stable film. DNA, antibodies, enzymes, and peptides all have been patterned onto arrays at Sandia using this chemistry. After treating the sensor with the target solution, the array is washed and treated with a different solution containing molecules that bind to the other end of the target biomolecule, forming a "sandwich." These secondary labels form an electroactive product that is detected by the electrode. The team is also investigating a new electrochemical detection method using electrocatalytic nanoparticles that they hope will eliminate the extra washing and labeling steps, which will greatly simplify the end device. Eventually the sensor array will be integrated in a deployable electrochemical sensor that will have an electronic readout identifying the biomolecules detected, or wirelessly transmit the results to a computer or network. Reaching that point likely will take anywhere from two to five years. Currently, Sandia and CombiMatrix, a company that specializes in producing semiconductor arrays with more than 12,000 individually addressable electrodes in an area less than one inch square, are pursuing a cooperative research and development agreement for further development of a sensor using Sandia's surface chemistry and CombiMatrix's electrode array, ultimately to test for thousands of biomolecules simultaneously.

<http://www.sandia.gov/news/resources/releases/2007/sensor.html>

New Sensor System Improves Detection of Lead, Heavy Metals: PNNL Develops Inexpensive Portable Detection System for Rapid, Accurate Analysis of Toxic Metals
Pacific Northwest National Laboratory News Release, 12 Feb 2008

DOE's Pacific Northwest National Laboratory has developed a new rapid, portable and inexpensive detection system that identifies personal exposures to toxic lead and other dangerous heavy metals. The device can provide an accurate blood sample measurement from a simple finger prick, which is particularly important when sampling children. PNNL's portable analyzer system accurately detects lead and other toxic metals in blood as well as in urine and saliva. Results are as reliable as those of current state-of-the-art mass spectrometry systems many times its size. This new system provides a quicker, simpler and easier method of monitoring toxic metal exposures in high-risk populations, such as industrial workers, children and people living in polluted areas. A bit larger than a lunchbox, the new detection system is field-deployable with plug-and-play features that allow different sensors to be easily exchanged to detect a variety of heavy metal toxins. The entire system is battery-operated and requires about one and one-half times the power of a typical laptop computer. The system also routinely delivers reliable measurements within a rapid two-to-five minute analysis period. Early production cost estimates indicate that the device may be as much as 10 times less expensive than existing plasma mass spectrometry systems, which lack field portability and require samples to be returned to the lab for time-consuming and more expensive analysis. The device can use two classes of sensors for detecting lead and other heavy metals. The first is based on a flow injection system using a mercury-film electrode to analyze metals. To eliminate the use of toxic mercury in conducting the analysis, the second class of the sensor uses a mercury-free approach of nanostructure materials developed at PNNL. This involves use of either Self-Assembled Monolayers on Mesoporous Supports -- SAMMS(tm) technology -- or functionalized magnetic nanoparticles that provide excellent detection sensitivity at a ppb level.

<http://www.pnl.gov/news/release.asp?id=297>

A New Tracer Technique for Monitoring Groundwater Fluxes: The Finite Volume Point Dilution Method

Brouyere, S. (Univ. of Liege, Belgium), J. Batlle-Aguilar, P. Goderniaux, and A. Dassargues. Journal of Contaminant Hydrology, Vol 95 Nos 3-4, p 121-140, 28 Jan 2008

Quantification of pollutant mass fluxes is essential for assessing the impact of contaminated sites on their surrounding environment. A new tracer technique--the finite volume point dilution method (FVPDM)--is proposed that generalizes the single-well point dilution method to the case of finite volumes of tracer fluid and water flush. The method is based on an analytical solution derived from a mathematical model recently proposed to model tracer injection into a well. Using a non-dimensional formulation of the analytical solution, a sensitivity analysis is performed on the concentration evolution in the injection well, according to tracer injection conditions and well/aquifer interactions. Based on this analysis, optimized field techniques and interpretation methods are proposed. The new tracer technique is easier to implement in the field than the classical point dilution method and in addition allows monitoring temporal changes of the magnitude of estimated Darcy fluxes. The new technique was applied to two sites with contrasting objectives, geological and hydrogeological conditions, and field equipment facilities. In both cases, field tracer concentrations monitored in the injection wells were used to fit the calculated modelled concentrations by adjusting the apparent Darcy flux

crossing the well screens. The methodology is efficient and accurate, with a wide range of potential applications in different environments and experimental conditions, including the monitoring with time of changes in Darcy fluxes.

Novel Carotenoid-Based Biosensor for Simple Visual Detection of Arsenite: Characterization and Preliminary Evaluation for Environmental Application

Yoshida, K., K. Inoue, Y. Takahashi, S. Ueda, K. Isoda, K. Yagi, and I. Maeda.

Applied and Environmental Microbiology, [e-pub ahead of print], 2008

A novel whole-cell arsenite biosensor has been developed using the photosynthetic bacterium *Rhodospseudomonas palustris* no. 7. A sensor plasmid containing the operator/promoter region of the *ars* operon and *arsR* gene, from *Escherichia coli*, and the *crtI* gene, from *Rhodospseudomonas palustris* no. 7, was introduced into a blue-green *crtI*-deleted mutant, *Rhodospseudomonas palustris* no. 711. The biosensor changed color in response to arsenite, and this change was obvious to the naked eye after 24 hrs without further manipulation. Real-time RT-PCR showed the *crtI* mRNA was induced 3-fold at 3 hrs and 2.5-fold at 6 hrs after 50 ug/L arsenite addition compared with the no-arsenite control. The relative level of lycopene and rhodopin also increased compared with the control. Colorimetric analysis of the bacteria showed hue angle had clearly shifted from green-yellow toward the red in an arsenic dose-dependent manner at 24 hrs after arsenite addition. This obvious shift occurred irrespective of the culture conditions before arsenite was added, indicating that the biosensor displays a stable color change in water samples containing various concentrations of dissolved oxygen. Assays using samples prepared in various mineral waters indicated that this biosensor could be used to screen groundwater samples for arsenite in a variety of locations, including remote areas where electricity is not available.

On-Line Monitoring of Remediation Process of Chromium Polluted Soil Using LIBS

Gondal, M.A., T. Hussain, Z.H. Yamani, and M.A. Baig, King Fahd Univ. of Petroleum & Minerals, Dhahran, Saudi Arabia.

Journal of Hazardous Materials, [e-pub ahead of print], 2008

Laser-induced breakdown spectroscopy (LIBS) was used in the laboratory to monitor the remediation of chromium-contaminated soil. The containerized setup was designed to simulate actual field conditions. For generation of the LIBS spectrum, plasma was produced by focusing a pulsed Nd:YAG laser at 1,064 nm on the contaminated soil undergoing the remediation process. The minimum detection limit of the spectrometer for chromium in the soil matrix was 2 mg/kg. Optimal experimental conditions were evaluated for improving the sensitivity of the LIBS system for monitoring remediation progress through a parametric dependence study.

Passive Electrical Monitoring of Aerobic and Anaerobic Processes Using Septic Systems as an Analog

Paine, Jeffrey, Univ. of Texas at Austin.

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Philadelphia, PA. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 255-263, 2008

Researchers used anaerobic and aerobic septic systems as analogs to investigate whether the passive electrical potential (SP) method can be used to detect and monitor shallow biochemical reactions. High-resolution SP surveys conducted with nonpolarizing electrodes can reliably detect potential differences as small as a few mV over relatively small areas, suggesting that the technique can find wider use in monitoring biodegradation processes, mapping effluent plumes, and identifying local preferential infiltration areas. Surface SP measurements appear to respond to changes in the oxidation-reduction potential in shallow reactors, correlating best with changes in dissolved oxygen concentration and measured electrical potential within the subsurface reactors. Among the available electrode choices, only nonpolarizing electrodes, such as the copper/copper sulfate types, provided the measurement stability necessary to achieve high-resolution results. <http://www.beg.utexas.edu/staffinfo/paine-pubs/126.pdf>

Passive Sampling and Analyses of Common Dissolved Fixed Gases in Groundwater

Spalding, B.P. and D.B. Watson, Oak Ridge National Lab, TN.

Environmental Science & Technology, Vol 42 No 10, p 3766-3772, 15 May 2008

An in situ passive sampling and gas chromatographic protocol was developed for analysis of major and minor fixed gases (He, Ne, H₂, N₂, O₂, CO, CH₄, CO₂, and N₂O) in groundwater. Using argon carrier gas, a HayeSep DB porous polymer phase, and sequential thermal conductivity and reductive gas detectors, the protocol achieved sufficient separation and sensitivity to measure the mixing ratio of all the gases in a single 0.5 mL gas sample collected in situ, stored, transported, and injected using a gas-tight syringe. Whether initially filled with helium or air, the sampler attained an equivalent and constant mixing ratio for 5 of the 7 detected gases within 4 days of immersion in groundwater. The abundant mixing ratio of nitrous oxide, averaging 2.6%, indicated that significant denitrification likely is ongoing within groundwater contaminated with uranium, acidity, nitrate, and organic carbon from a group of four closed radioactive wastewater seepage ponds.

Pesticide Analysis by MEKC on a Microchip with Hydrodynamic Injection from Organic Extract

Smirnova, A., K. Shimura, A. Hibara, M.A. Proskurnin, and T. Kitamori.

Journal of Separation Science, Vol 31 No 5, p 904-908, Mar 2008

An integrated microchip for monitoring carbamate pesticides in environmental water uses integrated continuous-flow chemical processes--hydrolysis, azo-derivatization, liquid-liquid extraction, electrophoretic separation, and quantification. The separation of the derivatives of four carbamate pesticides (carbaryl, carbofuran, propoxur, and bendiocarb) extracted in the continuous flow of a 1-butanol phase was studied in a silica microchip using micellar EKC. A baseline separation of four pesticide derivatives was achieved on a silica chip using hydrodynamic injection with electroosmotic gating. Detection using a thermal lens microscope showed good linearity in the concentration range of 10⁻⁶ -10⁻⁵ M with an LOD of 5 x 10⁻⁷

M, which is superior to that of conventional CE with UV absorption detection at a level of 10^{-4} M.

Phytoremediation of Mixed-Contaminated Soil Using the Hyperaccumulator Plant *Alyssum lesbiacum*: Evidence of Histidine as a Measure of Phytoextractable Nickel
Singer, A.C., T. Bell, C.A. Heywood, J.A.C. Smith, and I.P. Thompson.
Environmental Pollution, Vol 147 No 1, p 74-82, 2007

An investigation of the effects of PAHs (phenanthrene and chrysene) on the ability of the hyperaccumulator plant *Alyssum lesbiacum* to phytoextract nickel from co-contaminated soil was conducted in planted and unplanted mesocosms. The contaminated soils were amended repeatedly with sorbitan trioleate, salicylic acid, and histidine in various combinations to enhance the degradation of the two PAHs and increase nickel phytoextraction. The PAHs had a negative effect on plant growth but no significant effect on the phytoextraction of Ni per unit biomass of shoot. Exogenous histidine did not increase nickel phytoextraction, but the histidine-extractable fraction of soil nickel showed a high correlation with phytoextractable nickel. These results indicate that *A. lesbiacum* might be effective in phytoextracting nickel from marginally PAH-contaminated soils. The results also provide evidence for the broader applicability of histidine for quantifying and predicting Ni phytoavailability in soils; *A. lesbiacum* phytoextracted nickel from PAH-contaminated soils from which the pool of nickel accessed for phytoextraction was closely modeled by a histidine/soil extract.

Pitfalls in Compound-Specific Isotope Analysis of Environmental Samples
Blessing, M. (Eberhard Karls Univ. of Tuebingen); M.A. Jochmann and T.C. Schmidt (Univ. Duisburg-Essen, Germany).
Analytical and Bioanalytical Chemistry, Vol 390 No 2, p 591-603, Jan 2008

In this review, potential pitfalls of the compound-specific stable isotope analysis (CSIA) procedure are discussed with strategies to avoid possible sources of error. To maintain analytical quality and ensure the basis for reliable stable isotope data, recommendations are given on groundwater sampling and sample preservation and storage. Important aspects of sample preparation and preconcentration techniques to improve sensitivity are highlighted. Factors related to chromatographic resolution and matrix interference require consideration to achieve accurate gas chromatography/isotope ratio mass spectrometry measurements. The need for a thorough investigation of CSI fractionation effects introduced by any step of the overall analytical method by standards with known isotopic composition is emphasized. The reviewers add important points to consider when interpreting data from field investigations.

Plant Sampling for Groundwater Investigations: Plume Delineation, Contaminant Degradation and Improved Detection Limits

Burken, J.G. and E. Sheehan (Univ. of Missouri-Rolla); P. Mayer, U. Karlson, and C. Legind (Danish National Environmental Research Inst.).

Abstracts: Fourth International Phytotechnologies Conference, 24-26 September 2007, Denver, Colorado: Abstracts, p 4, 2007

Tree-core analysis has been shown to provide a rapid, semi-quantitative delineation of VOC-contaminated soil and groundwater with minimal cost and impact to property. Case studies show benefits and concerns for sampling chlorinated solvents using tree-coring methods. Methods described in this presentation have led to detection of degradation products, showing the potential of monitoring natural attenuation using plant sampling methods. Sampling plant matrices can be challenging given variable volatility of compounds and the difficulty in quantifying low levels in plant tissues due to mass-limited headspace sampling. Using newly developed methods, in-plant sampling can be accomplished with much lower detection levels as mass limitations are essentially nonexistent because the entire tree is the sample size. Overall method detection limits are reduced by several fold, and the metabolic products detected give evidence of natural attenuation or remedial efficacy.

The Power of Pathlength: SoloVPE--Variable Pathlength Extension, C Technologies, Inc., Bridgewater, N.J.

R&D Daily, 9 Oct 2008

Spectroscopists have long worked in a world where pathlength was considered to be a constant by developing techniques and methods around the fixed pathlength cuvettes available to them. The SoloVPE--Variable Pathlength Extension from C Technologies, Inc., Bridgewater, N.J.--can use dynamically varying optical pathlengths, thus enabling absorption measurements of highly concentrated samples without dilution. The SoloVPE is designed to make absorption measurements in the UV, visible, and near-infrared on samples with a wide range of absorptions. It achieves this flexibility by dynamically varying the measurement pathlength by integrating optical fiber, a stepper motor, and linear actuator technology with control software to provide thousands of different pathlengths on demand. This maximizes the dynamic range, sensitivity, and resolution of the instrument. The system generates absorbance vs. pathlength plots in real time with data acquisition, a unique capability among lab spectrophotometers. This device has received a R&D 100 2008 award in the category of Analytical Instruments.

Prototype Development of Three Bi-Directional Autonomous Groundwater/Surface Water Seepage Meters

Lee, P.Z., L. Wu, C.B. Jonas, and J.E. Palmer.

World Environmental and Water Resources Congress 2007: Restoring our Natural Habitat. American Society of Civil Engineers, Reston, VA. ISBN: 0784409277, 2007

Three different bi-directional autonomous groundwater/surface water seepage meter prototypes were collaboratively designed and developed from 2003 to 2006. All three seepage meters are self-contained automated systems that include a seepage collector, flow rate sensor, on-board controller, data logger, battery pack, and deployment/retrieval accessories. The first seepage meter design uses a Doppler flow rate sensor mounted on top of the seepage collector.

The second seepage meter design uses a thermal flow-rate sensor with detached seepage collectors. The latter design allows the use of multiple collectors to increase/decrease the measurement range of the meter. The three different meter sensors and collector combinations allow the measurement of seepage rates over a relatively wide range, with some overlap. All three seepage meters were tested in the lab and field and proved to be easy to deploy and retrieve, and were dependable for long-term operation and monitoring of groundwater/surface water interactions.

Quantifying Genes and Transcripts to Assess the in situ Physiology of "Dehalococcoides" spp. in a Trichloroethene-Contaminated Groundwater Site

Lee, P.K., T.W. Macbeth, K.S. Sorenson Jr., R.A. Deeb, and L. Alvarez-Cohen, Univ. of California, Berkeley.

Applied and Environmental Microbiology, Vol 74 No 9, p 2728-2739, May 2008

TCE-contaminated groundwater at Fort Lewis, WA, was subjected sequentially to biostimulation and bioaugmentation. Dehalococcoides cells carrying the three reductive dehalogenase (RDase) genes *tceA*, *vcrA*, and *bvcA* were indigenous to the site. Monitoring of the dechlorinating bacteria was undertaken using quantitative PCR (qPCR) coupled with reverse transcription to analyze both gene copy numbers and transcripts of the 16S rRNA gene and three RDase genes as biomarkers of the Dehalococcoides spp. The sum of the three identified RDase gene copy numbers closely correlated to 16S rRNA gene copy numbers throughout the biostimulation and bioaugmentation activity, suggesting that these RDase genes represented the major Dehalococcoides metabolic functions at this site. Biomarker quantification revealed an overall increase of more than 3 orders of magnitude in the total Dehalococcoides population through the 1-year monitoring period (spanning biostimulation and bioaugmentation), and measurement of the respective RDase gene concentrations indicated different growth dynamics among Dehalococcoides cells. Results show that quantification of biomarker dynamics at field sites can provide useful information about the in situ physiology of Dehalococcoides strains and their associated activity during remediation.

Rapid Aryl Hydrocarbon Receptor Based Polymerase Chain Reaction Screening Assay for Polychlorinated Dibenzo-p-Dioxins and Furans in Soil and Sediment

McAlister, D.R., M.J. Fern, and R.L. Allen, Eichrom Technologies, LLC, Darien, IL.

Talanta, Vol 74 No 4, p 992-997, 15 Jan 2008

A method for the estimation of polychlorinated dibenzo-p-dioxin and furan (PCDD/F) toxicity equivalent quotient (TEQ) of soil and sediment matrices involves extraction, isolation of the PCDD/Fs from interfering compounds (e.g., PCBs and PAHs), and measurement of PCDD/F using the PROCEPT aryl hydrocarbon receptor-based polymerase chain-reaction assay. The values obtained using the PROCEPT assay correlate well with reference TEQ values generated from gas chromatography/high-resolution mass spectrometry, with a linearity coefficient of 0.94. Applied in a screening mode at 50 pg/g PCDD/F TEQ, the PROCEPT assay yielded five false positive results (2.6%) and no false negative results for 196 analyses of spiked soils and samples obtained from EPA Superfund sites.

Rapid Detection of Picloram in Agricultural Field Samples Using a Disposable Immunomembrane-Based Electrochemical Sensor

Tang, L., G.M. Zeng, G.L. Shen, Y.P. Li, Y. Zhang, and D.L. Huang, Hunan Univ., Changsha, China.

Environmental Science & Technology, Vol 42 No 4, p 1207-1212, 15 Feb 2008

To establish a rapid and sensitive method for accurate detection of trace picloram (a chlorinated herbicide) in agricultural samples, the authors employed a disposable, nontoxic, and conductive chitosan/gold nanoparticle composite membrane on an electrochemical sensor for the sensitive detection of picloram in several agricultural field samples. A self-synthesized picloram antibody was encapsulated in the immunomembrane to form an immunoconjugate by a competitive immunoreaction in sample solution, followed by the immobilization of a horseradish peroxidase (HRP)-labeled secondary antibody. The immunomembrane possessed good reproducibility for batch fabrication. The diffused colloidal Au nanoparticles shuttled the electron transfer between the immobilized HRP and the electrode surface. To test the sensor, rice, lettuce, and paddy field water were spiked with picloram and assayed without preconcentration. Under optimal conditions, picloram could be detected from 0.005 to 10 ug/mL (with a correlation coefficient of 0.9937) at a detection limit of 5 ng/ mL. The device exhibited good precision, sensitivity, selectivity, and storage stability.

Recent Biosensing Developments in Environmental Security

Wanekaya, A.K., W. Chen, and A. Mulchandani, Missouri State Univ., Springfield.

Journal of Environmental Monitoring, 10 No 6, p 703-712, June 2008

Because of their integrated nature, biosensors are ideal for environmental monitoring and detection as they can be portable and provide selective and sensitive rapid responses in real time. The authors discuss the main concepts behind the development of biosensors that have relevant applications in the field of environmental monitoring and detection and also review and document recent trends and challenges in biosensor research and development, particularly in the detection organophosphate nerve agents, heavy metals, organic contaminants, and pathogenic microorganisms and their toxins. Emphasis is given to the trends that have the most promising applications in environmental security.

<http://www.engr.ucr.edu/~wilfred/>

Residential Vapor-Intrusion Evaluation: Long-Duration Passive Sampling vs. Short-Duration Active Sampling

Odencrantz, J.E., H. O'Neill, S.J. Steinmacher, J.D. Case, and P.C. Johnson.

Remediation Journal, Vol 18 No 4, p 49-54, 2008

Sampling indoor air for potential vapor-intrusion impacts using current standard 24-hour sample collection methods may not account adequately for temporal variability. Henry Schuver of U.S. EPA's Office of Solid Waste stated at the September 2007 Air & Waste Management Association vapor-intrusion conference that EPA may consider recommending longer-term vapor sampling to achieve more accurate time-weighted-average detection. In November 2007, indoor air at four residences was sampled to measure TCE concentrations over short- and long-duration intervals. The investigation consisted of triplicate samplers for three different investigatory methods: dedicated 6-liter Summa canisters (US EPA Method TO-15),

pump/sorbent tubes (US EPA Method TO-17), and passive diffusion samplers (MDHS 80). The first two methods collected samples simultaneously for a 24-hour period, and the third method collected samples for two weeks. Data collected using Methods TO-15 (canisters) and TO-17 (tubes) provided reliable short-duration TCE concentrations that agree with prior 24-hour sampling events in each of the residences; however, the passive diffusion samplers may provide a more representative time-weighted measurement. The ratio of measured TCE concentrations between the canisters and tubes are consistent with previous results. This paper compares the sampling procedures and details the findings from the three methods used in the study.

http://www.beacon-usa.com/pdf/Indoor_Air_Method_Comparison.pdf

Resistivity Variation with Biodegradation in a Refinery Oil Dump in Brazil

Castilho, G., D. Maia, and M. Pessoa, Brain Tecnologia Ltd, Brazil.

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 241-247, 2007

The geoelectrical response of an oil-contaminated site has been examined in several studies over the last few years. Researchers have monitored the time-related changes of the oil's physical properties, such as resistivity, due to bacterial degradation. A large area in an oil refinery in Brazil was used years ago as a hydrocarbon dump. The site was later graded. A site investigation of the extent of the contamination comprised 171 2-D electrical surveys, 186 2-D GPR lines, 10400 sq m of 3-D GPR data, and 101 drill holes with complete geochemical data. The geophysical data showed a good agreement with the geochemical analysis regarding the location of the hydrocarbon contamination. Contaminated regions presented a positive or negative electrical resistivity contrast with the soil background, depending on the biodegradation level. Deeper oil samples presented an electrical resistivity two orders of magnitude below the shallower ones. These results combined with analysis of TPH levels confirmed earlier laboratory measurements that associated the decrease in electrical resistivity with biodegradation.

RiboSyn is a New Method for Measuring Specific Growth Rates of Distinct Microbial Populations in Natural Systems

Rocha, A.M., M.R. Cutter, S.J. DuPont, and P.G. Stroot.

World Environmental and Water Resources Congress 2007: Restoring our Natural Habitat. American Society of Civil Engineers, Reston, VA. ISBN: 0784409277, 2007

The RiboSyn method was developed to measure the specific growth rates of distinct microbial populations by determining the specific rate of ribosome synthesis. In this technique, cells are exposed to chloramphenicol, which inhibits the processing of pre16S rRNA to 16S rRNA. Using reverse transcription and primer extension, the ratio of pre16S rRNA to 16S rRNA can be measured and ribosome doubling time determined. Due to RT-RiboSyn's ability to target specific nucleotide sequences, the specific growth rate of distinct microbial populations in mixed cultures can be determined. The RiboSyn method can be used parallel with fluorescent in situ hybridization (FISH) to identify and measure growth rates of individual populations of bacteria in mixed assemblages. The ability to measure specific growth rates of distinct microbial populations in a sample from a natural system can improve understanding of the microbial processes responsible for the transformation of chemical contaminants in the environment.

The Role of Continuous Groundwater Level Monitoring in the Assessment of Phytoremediation Performance

Quinn, J. and R. Johnson, Argonne National Laboratory.

International Conference and Training -- Triad Investigations: New Approaches and Innovative Strategies, June 10-12, 2008, University of Massachusetts at Amherst. Program Abstracts, p 42 (poster abstract), 2008

At the Argonne National Laboratory phytoremediation site in northeastern Illinois, a network of movable probes has provided hourly water-level data, almost uninterrupted, since 1999 at a stratigraphically complex site with over 800 hybrid poplars and willows planted as part of a phytoremediation system to address VOC and radionuclide contamination in groundwater. The coverage of the probes has included over 20 monitoring wells screened in distinct hydrogeologic units. To date, the probes have generated more than 400,000 data points. Inspection of the data at short time scales (hourly to daily) has provided detailed information pertinent to the diurnal water table fluctuations attributed to the plantation. Over longer time scales, the degree of hydraulic containment provided by the phreatophytes is also being evaluated. The temporally dense depth-to-water table data has resulted in an unanticipated, complete revision of the conceptual site model. The data from the water-level probes identified a previously unsuspected subsurface site infrastructure issue that turned out to be a significant controlling factor for groundwater movement and the fate and transport of dissolved-phase contaminants. The experience of the phytoremediation monitoring system at Argonne underscored the value of spatially and temporally dense data sets for the proper design and operation of subsurface remediation systems.

Sampling VOCs with Porous Suction Samplers in the Presence of Ethanol: How Much Are We Losing?

Freitas, J.G. and J.F. Barker.

Ground Water Monitoring & Remediation, Vol 28 No 3, p 83-92, 2008

Previous studies have identified mechanisms, such as volatilization and sorption, that may compromise the representativeness of groundwater samples acquired from the vadose zone using porous suction samplers, particularly when dealing with VOCs like gasoline. Ethanol is common in modern fuels and so may be present in groundwater contaminated by fuel releases. In lab experiments, the authors evaluated the losses of VOCs (trimethylbenzenes, benzene, toluene, xylenes, and naphthalene) in the presence of different volumetric fractions of ethanol when using porous suction samplers. Significant losses were found up to 30% for ethylbenzene. Ethanol affected the accuracy of the readings negatively, by increasing the headspace in the sampling tube, and also positively, by increasing partition to the aqueous phase due to the cosolvent effect and therefore decreasing the mass loss by volatilization. Consequently, the highest losses of VOCs were found at intermediate ethanol volume fractions: 10% and 20% (v/v). The losses can be anticipated by measuring the ratio of gas to water in the sampling line and then by applying simple partition models considering cosolvency by ethanol. The importance of adequate purging when using porous suction samplers also is discussed.

Sandia's Unattended Water Sensor Capable of 24/7 Detection of Toxins, Bacteria in Water Supplies: Device Now Deployed for Testing at Municipal Water Station in Arizona
Sandia National Laboratory News Release, 9 May 2007

In late 2004, Sandia National Laboratories announced a multiyear research agreement with Tenix Investments Pty. Ltd. to develop a method for constantly monitoring water for biological pathogens. Sandia's unattended water sensor (UWS) has successfully undergone testing at a large Bay Area water utility for more than a year and recently has been deployed to a municipal water station in Arizona for additional observation and adjustments. The UWS in Arizona is expected to operate for at least three months. Staff will perform periodic maintenance and troubleshooting on the system, which is expected to demonstrate the viability of unattended water monitoring. The next phase of the project will be to develop a product suitable for use by the water industry. Other applications for the UWS include monitoring agricultural water for contaminants, as well as water provided to sports stadiums and other venues. The UWS is a box (17 in high by 14 inches wide by 7 inches deep) that contains analytic instruments, pumps, tubes, and small reservoirs to handle minute amounts of fluid. The reservoirs contain chemical buffers, fluorescent dyes, proteins, and separation gel. This innovative diagnostic instrumentation package, based on Sandia's well-known MicroChemLab technology, is mounted near the water supply. The box is connected to a small, submerged probe that transports the sample into the system. Largely due to the automated sample preparation, the UWS is currently able to achieve sample analysis in just 12 minutes--a significant improvement over the original goal of 30 minutes or less. The UWS is currently able to detect protein toxins such as SEB, botulinum, and ricin. The next phase will expand the device's detection capability to include bacteria such as *E. coli* and protozoa such as *Cryptosporidium*. The researchers need to configure a working database of organism signatures to allow them to distinguish the signatures from one another. Sandia and its partners then would like to bring the system to an EPA facility or the U.S. Army's Edgewood Chemical Biological Center, where it can be tested in a real-world environment that includes analysis on bona fide toxic agents situated in authentic water supply conditions.
<http://www.sandia.gov/news/resources/releases/2007/watersensor.html>

Second International Workshop on Remote Sensing of Emissions: New Technologies and Recent Work

U.S. EPA, Office of Air Quality Planning and Standards, 523 pp, May 2008

This workshop was held April 1-3, 2008, under the sponsorship of EPA's Office of Air Quality Planning and Standards, Office of Research and Development, and Office of Solid Waste and Emergency Response. This workshop was held to discuss remote sensing developments that have occurred since the first meeting in 2006. Presentations were given on surveys taken using solar occultation flux and differential absorption light (DIAL) detection and ranging systems in the area of Houston, Texas; monitoring for pipeline gas leaks with an aircraft-mounted DIAL system; the results of an ongoing two-year continuous fenceline Fourier transform infrared spectroscopy (FTIR) activity at a petrochemical plant; the use of vertical radial plume mapping (VRPM) to measure landfill fugitive gas emissions and mercury emissions from a chlor-alkali plant; a fully automated VRPM tunable diode laser absorption spectroscopy system for continuous monitoring of lagoons at consolidated animal feeding operations; the use of FTIR fenceline monitoring at manufactured gas plant cleanups; and a research update on equipment being developed to detect in the mid to far infrared spectrum that does not require

cryogenic cooling. Also discussed were the implications for facility monitoring as these cutting edge tools become more commonplace and how to promote their use to reduce overall emissions. The workshop resulted in suggestions and recommendations for future actions to be taken by the various entities represented at the meeting. <http://www.clu-in.org/techdrct/techpubs.asp>

Sniffing Out a Better Chemical Sensor

NIST Tech Beat, 28 Oct 2008

Marrying a sensitive detector technology capable of distinguishing hundreds of different chemical compounds with a pattern-recognition module that mimics the way animals recognize odors, researchers at the National Institute of Standards and Technology have created a new approach for "electronic noses." Described in a paper in *Analytical Technology* (released on the Web 10/15/08), their electronic nose is more adept than conventional methodologies at recognizing molecular features--even for chemicals it has not been trained to detect--and is also robust enough to deal with changes in sensor response that come with wear and tear. The detector could be a potent tool for detecting nerve agents, environmental contaminants, and trace indicators of disease, in addition to monitoring industrial processes. In animals, odorant molecules in the air enter the nostrils and bind with sensory neurons in the nose that convert the chemical interactions into an electrical signal that the brain interprets as a smell. In humans, there are about 350 types of sensory neurons and many copies of each type; dogs and mice have several hundreds more types of sensory neurons than that. Odor recognition proceeds in a step-by-step fashion where the chemical identity is gradually resolved: initial coarse information (e.g., ice-cream is fruit-flavored vs. chocolate) is refined over time to allow finer discrimination (strawberry vs. raspberry). This biological approach inspired the researchers to develop a parallel method for use with the electronic nose. The technology is based on interactions between chemical species and semiconducting sensing materials placed on top of MEMS microheater platforms developed at NIST. The current electronic nose is comprised of eight types of sensors in the form of oxide films deposited on the surfaces of 16 microheaters, with two copies of each material. Precise control of the individual heating elements allows the scientists to treat each of them as a collection of "virtual" sensors at 350 temperature increments between 150 to 500 degrees C, increasing the number of sensors to about 5,600. The combination of the sensing films and the ability to vary the temperature gives the device the analytical equivalent of a snout full of sensory neurons. The electronic nose must be trained to recognize the chemical signatures of different smells before it can deal with unknowns. The study, "Bioinspired Methodology for Artificial Olfaction," is available for purchase through the American Chemical Society. http://www.nist.gov/public_affairs/techbeat/current.htm#nose

Spatial Analysis of Optimized Sensor Locations Using GIS

Isovitsch, S.L. and J.M. VanBriesen.

World Environmental and Water Resources Congress 2007: Restoring our Natural Habitat. American Society of Civil Engineers, Reston, VA. ISBN: 0784409277, 2007

A water distribution system was analyzed for optimal sensor placement based on four different intrusion scenarios and five different optimization criteria cases. A 5-sensor network and a 20-sensor network were developed for each scenario and optimization case, resulting in 40 individual sensor networks, each corresponding to a different scenario, case, and number of

sensors that form the network. Frequency and average nearest neighbor analyses indicated that sensor placements corresponding to the different intrusion scenarios and optimization cases are likely to overlap and cluster. Analysis of the dependence of sensor location on demand characteristics illustrated that sensor locations defined by optimizing volume of consumed contaminated water and amount of population affected are likely to be dependent on network nodes with a high reachable average demand, and sensor locations defined by optimizing detection likelihood are likely to be dependent on network nodes with a low reachable average demand.

Speciation Analysis of Arsenic, Chromium and Selenium in Aquatic Media: Proceedings of a Final Research Coordination Meeting Held in Vienna, 26-29 April 2004.

International Atomic Energy Association, Vienna, Austria. IAEA-TECDOC-1542, ISBN: 92-0-101507-0, 98 pp, Mar 2007

This publication presents the results of a project analysing the speciation of As(+3)/As(+5), Cr(+3)/Cr(+6) and Se(+4)/Se(+6) in water samples. Total element concentration does generally not provide adequate information to understand the effects of trace and heavy metals observed in the environment and in living systems. The toxicity, bioavailability, physiological and metabolic processes, and the mobility and fate of elements are, to a large extent, dependent on the specific chemical form of an element. Speciation analysis has yet to be developed to its full potential for biochemical, clinical and environmental investigations, and still more work is needed in the near future; however, nuclear techniques, particularly the use of radioisotopes, can help in method development, optimization and stability tests of chemical species. http://www-pub.iaea.org/MTCD/publications/PDF/te_1542_web.pdf

Strategies for Monitoring the Emerging Polar Organic Contaminants in Water with Emphasis on Integrative Passive Sampling

Soderstrom, H., R.H. Lindberg, and J. Fick, Umea Univ., Sweden.

Journal of Chromatography A, [e-pub ahead of print], 2008

The authors review the benefits and drawbacks of using active and biological sampling and conclude the usefulness of biological sampling of POCs in water is limited. A detailed overview of the types of polar organic passive samplers (PS) available, the suitable classes of target compounds, and field of applications also addresses the environmental and quality control considerations involved in using them. The authors find that polar organic PS is the only available efficient alternative to active water sampling. Although the method offers simplicity, low cost, no maintenance, no need of a power supply, and the ability to collect time-integrative samples with one sample collection, it does require further development before it can be used as standard in water quality monitoring programs.

Stripping Analysis of Nanomolar Perchlorate in Drinking Water with a Voltammetric Ion-Selective Electrode Based on Thin-Layer Liquid Membrane

Kim, Y. and S. Amemiya, Univ. of Pittsburgh, Pittsburgh, PA.

Analytical Chemistry, Vol 80 No 15, p 6056-6065, 1 Aug 2008

A novel approach to enable the electrochemical detection of "redox-inactive" perchlorate at a nanomolar level without its electrolysis is based on a voltammetric ion-selective electrode. The perchlorate-selective electrode is based on a plasticized poly(vinyl chloride) membrane less than a micrometer thick spin-coated on a poly(3-octylthiophene)-modified gold electrode. The liquid membrane serves as the first thin-layer cell for ion-transfer stripping voltammetry to give low detection limits of 0.2 to 0.5 nM perchlorate in deionized water, commercial bottled water, and tap water under a rotating electrode configuration. The detection limits are not only much lower than the action limit (approximately 246 nM) set by EPA but also are comparable to the detection limits of the most sensitive analytical methods for detecting perchlorate, i.e., ion chromatography coupled with a suppressed conductivity detector (0.55 nM) or electrospray ionization mass spectrometry (0.20 to 0.25 nM).

T Tank Farm Interim Surface Barrier Demonstration -- Vadose Zone Monitoring FY07 Report

Zhang Z.F., C.E. Strickland, J.M. Keller, C.D. Wittreich, and H.A. Sydnor.

PNNL-17306, 2008

CH2M HILL Hanford Group, Inc. is constructing a temporary surface barrier over a portion of the T Tank Farm as part of the T farm Interim Surface Barrier Demonstration Project. The surface barrier is designed to prevent the infiltration of precipitation into the contaminated soil zone created by the Tank T-106 leak and minimize movement of the contamination. As part of the demonstration effort, vadose zone moisture monitoring is being performed to assess the effectiveness of the barrier at reducing soil moisture. A solar-powered and remotely-controlled system was installed to monitor soil water conditions continuously in four instrument nests (A, B, C, and D) along with the site meteorological condition. Each instrument nest is composed of a capacitance probe with multiple sensors, multiple heat-dissipation units, a neutron probe access tube, and a data logger. Nests A and B also contain a drain gauge. The principle variables monitored for this purpose are soil-water content, soil-water pressure, and soil-water flux. Soil temperature, precipitation, and air temperature are measured as well. Data from each of the dataloggers are transmitted remotely to the receiving computer. The neutron probe access tube is used to perform quarterly manual measurements of soil-water content using a neutron probe. This monitoring system is used to assess the soil water conditions in the soil outside and within the footprint of the surface barrier to be emplaced in the Hanford T Tank Farm.

<http://www.pnl.gov/publications/abstracts.asp?report=234001>

TapRoot(tm) Technology: Non-Invasive Plume Delineation

McDermott, J. (Union Pacific); M. Shurtliff, M. Mason, and J. Burken (The Forrester Group, Inc.). 2007 Railroad Environmental Conference, October 23-25, 2007: Abstracts.

Illinois Railroad Engineering Program, p 21 [poster abstract], 2007

The science of tree coring to detect the uptake of chemicals of environmental concern has matured significantly in recent years and tree coring is now being deployed for rapid, precise contaminant source and plume delineation. By combining tree-core analysis with highly accurate

GPS mapping of trees on site, solvent plume maps can be generated at a fraction of the cost of conventional investigation techniques. The spatial resolution that can be achieved leads to maps that can locate plume boundaries and source areas precisely in a single mobilization for sites of multiple acres in scale. Maps can be provided within days, compared to the weeks or months required for conventional investigative techniques. Groundwater contaminant delineation can also be accomplished at difficult locations that are inaccessible to direct push or drilling rigs, with minimal mobilization costs. The authors present case studies and methodologies to show how The Forrester Group's TapRoot(tm) Technology has been used at railroad sites and what information can be gained. Limitation of the methods, including compounds that can be analyzed and site characteristics that can be limiting to application are discussed.

Temporal Geophysical Investigations of the FT-2-Plume at the Wurtsmith Air Force Base, Oscoda, Michigan

Joyce, R., V. Che-Alota, C. Davis, E. Atekwana, E. Atekwana, B. Sauck, D. Werkema.

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Philadelphia, PA. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 241-254, 2008

The decommissioned former Fire Training Cell (FT-02) facility at Wurtsmith Air Force Base has been the focus of several geophysical investigations. Significant amounts of hydrocarbons and some solvents contaminate the vadose and saturated zones in the source area. Groundwater geochemistry studies defined a contaminant plume that was approximately 125 m wide and > 300 m long. The boundary of the plume was further defined by using GPR, SP, and resistivity techniques. The source of the geophysical anomalies was attributed to biogeochemical modifications of the contaminated zone resulting from intrinsic bioremediation. In 2007, additional GPR, SP, and electrical resistivity surveys were conducted with expectations of achieving results similar to those of past investigations; however, the investigators observed a marked decrease in geophysical response from all the geophysical techniques. The GPR anomaly had migrated deeper into the subsurface, the positive SP response was significantly attenuated, and the conductive resistivity anomaly had been replaced by background resistivity values. Six Geoprobe cores at three different locations were collected in order to conduct laboratory microbial counts and IP measurements. The observed geophysical anomalies are attributed to ongoing soil vapor extraction initiated in 2001; significant removal of the contaminant mass by the vapor extraction system altered the subsurface biogeochemical conditions. These changes were documented by the 2007 geophysical data. The data show that the attenuation of the contaminant plume can be detected with geophysical methods.

Theoretical Evaluation of a Method for Locating Gaseous Emission Hot Spots

Hashmonay, Ram A., ARCADIS, Inc., Durham, NC

Journal of the Air & Waste Management Association, Vol 58 No 8, Aug 2008

The horizontal radial plume mapping (HRPM) methodology uses an open-path, path-integrated optical remote sensing system in a horizontal plane to identify emission hot spots directly. Although HRPM has been applied mostly at landfills and a few wastewater treatment plants for locating methane emission hot spots, the method also has applications for spatial

characterization of other area and fugitive emission sources, such as contaminated soil and leaks from industrial facilities, using a variety of optical remote sensing technologies.

Three-Dimensional Depiction of Coal Tar in Soils and Sediments within the Overburden Stratigraphic Framework Using TarGOST(r)

Saroff, Scott, CH2M HILL

International Conference and Training -- Triad Investigations: New Approaches and Innovative Strategies, June 10-12, 2008, University of Massachusetts Amherst. Program Abstracts, p 21, 2008

Tar-specific Green Optical Screening Tool (TarGOST(r)) laser-induced fluorescence (LIF) survey data and Mining Visualization System (MVS(r)) software were used to delineate and illustrate in 3D coal tar found in upland soils and adjacent river sediments at a former roofing material manufacturing and petroleum bulk storage site in New Jersey. TarGOST(r) instrument LIF technology utilizes light-energy in the form of a green PSX-100 Excimer Laser(r) to energize and excite coal tar- and creosote-range hydrocarbons to fluoresce a characteristic wavelength of light, which is detected by the probe tip optical assembly. Upland, 93 TarGOST(r) LIF profiles were conducted to soil depths of approximately 37 feet to the confining layer using a Geoprobe(r) 6010 direct-push rig. For the river sediment, 49 TarGOST(r) profiles were conducted to depths of 50 feet. The TarGOST(r) results facilitated revision and refinement of the site conceptual site model, thereby saving considerable costs for site remediation. The vertical distribution of coal tar using TarGOST(r) data from each boring was interpolated using a 3D kriging model. Using lithology descriptions from more than 280 soil borings, the surfaces of key geologic units were created in the model using kriging. The 3D coal tar interpolation and geologic surfaces were combined with a base plan depicting surface features at the site to create a 3D geologic model illustrating the lateral and vertical extent of coal tar in the subsurface. Results indicate that the coal tar is not present as a single contiguous mass, but instead occurs in distinct isolated areas lying above and on top of the upland silty clay confining unit, and also as thin isolated layers in sediment to a smaller extent than previously had been interpreted.

Total Copper Analyzer for Rapid In Situ Characterization of Effluent Discharges: Cost & Performance Report

Environmental Security Technology Certification Program (ESTCP), Project SI-0311, 45 pp, Aug 2008

Water quality criteria for dissolved copper (Cu) in receiving bodies of water includes a freshwater criterion maximum concentration, also known as the acute value, of 13 ug/L or parts per billion (ppb), and a freshwater criterion continuous concentration, or chronic value, of 9 ug/L. Rapid, in-place characterization of total recoverable Cu in effluents can be accomplished by the total copper analyzer (TCA). This in-place characterization will allow for the rapid separation of the effluent between waters in compliance and waters in need of treatment, thus minimizing the volume of water sent for treatment and reducing operating costs. Conventional characterization of effluents is performed off-site with laboratory tests, with the associated costs and turnaround time, often taking weeks for processing. As the TCA will provide a means to verify that the discharge is within permit requirements for Cu, in near real-time and at the place of discharge, it will be a great asset for any regulated discharger, both private and public,

including DoD. This demonstration and validation of the TCA under industrial situations supports its use as a management tool in most situations. Agreement with Cu concentrations measured with the accepted graphite furnace atomic absorption and inductively coupled plasma mass spectrometry technologies supports the performance of the TCA in cases of saline waters with low organic matter content (i.e., discharges from dry docks); however, as the performance of the TCA did not meet the expectations under conditions of high organic matter (i.e., outfall of a wastewater treatment plant), the application of the TCA for regulatory purposes is not warranted.

<http://www.estcp.org/viewfile.cfm?Doc=SI%2D0311%2DC%26P%2Epdf>

Uncertainty Determination for Nondestructive Chemical Analytical Methods Using Field Data and Application to XRF Analysis for Lead

Bartley, D.L., J.E. Slaven, M.C. Rose, M.E. Andrew, and M. Harper.
NIOSH, Cincinnati, OH.

Journal of Occupational Environmental Hygiene, Vol 4 No 12, p 931-42, Dec 2007

A portable X-ray fluorescence (XRF) analyzer was used to determine the lead content of air filter samples from several workplaces. The portable XRF method has the advantage of allowing for faster decisions compared with the alternative of submitting the air samples to an off-site laboratory for analysis. Because the XRF method is nondestructive, the same air samples also could be subjected to the reference laboratory-based method of analysis. Two statistical approaches were developed specifically to deal with non-normal elements of the data in evaluating the results. The ISO GUM method identifies outliers and then calculates an accuracy range about the true concentration for the remainder of the data. This coverage is then adjusted to account for the rate of outlier occurrence. The bootstrap procedure uses a large number of computer-generated data points that are sampled, with replacement, from the original set, including outliers to determine the coverage. No significant difference is seen between the two statistical approaches. Both approaches result in similar coverage and support the adoption of method acceptance criteria specific to field evaluation, a symmetric accuracy range of 35%. The portable XRF analyzer met this criterion when used with several different sampling methods and thus could be used as a method for routine evaluation of compliance with lead-limit values. As the method is nondestructive, further analysis of air samples with analytical results near decision points is possible.

The Use of Affymetrix(r) DNA Microarray Populus GeneChips(r) to Identify Phytotoxic Responses of Hybrid Poplar Trees (Populus deltoids x nigra DN34) During Uptake and Phytoremediation of TNT

Flokstra, B.R. and J.L. Schnoor, Univ. of Iowa, Iowa City.

Abstracts: Fourth International Phytotechnologies Conference, 24-26 September 2007, Denver, Colorado: Abstracts, p 24, 2007

Laboratory and field experiments using hybrid poplar trees for phytoremediation of TNT have determined that TNT is bound primarily in the roots and remains there during biotransformation and mineralization. Further research into the genetic mechanisms involved in this remediation process is needed. With the recent advent of the Populus Genechip(r) by Affymetrix(r), studies on the genetic effects of toxic substances to poplars during

phytoremediation of hazardous explosives are now possible. The Affymetrix(r) Populus microarray contains over 55,000 Populus genes, including built-in poplar probes, controls and rRNA probes. The authors describe endeavors to determine significant genetic responses during the phytoremediation of TNT within the root system of hybrid poplars. Populus deltoids x nigra DN34 cuttings were exposed to 5mg/L TNT, a predetermined threshold concentration for phytotoxicity. Previous lab studies indicated that TNT is removed from the aqueous solution by poplar cuttings within 48 hours of initial exposure. Multiple plants were sacrificed at 0, 8, 24, and 48 hours, and RNA was extracted from the roots. RNA was analyzed using the Agilent Bioanalyzer for purity, RNA peaks, and concentration. The best three samples from each time point were selected for hybridization to the Affymetrix(r) Populus microarray. The large quantity of genetic data collected from the triplicates at the four time points (12 microarrays) was processed using the biostatistical programs R and ArrayAssist(r) in conjunction with the Affymetrix(r) gene library and the on-line JGI poplar tree databases. Preliminary results of a significance analysis of the time course experiment indicate that the genetic areas affected most significantly are carbohydrate transport and metabolism, transcription, posttranslational modification and protein turnover, and lipid transport and metabolism. Energy cycles, such as the TCA cycle, also were affected, as well as many genes involved in photosystems I and II and metal-ion binding.

Use of Handheld X-Ray Fluorescence Spectrometry Units for Identification of Arsenic in Treated Wood

Block, C., T. Shibata, H. Solo-Gabriele, and T. Townsend.
Environmental Pollution, Vol 148 No 2, p 627-633, 2007

Experiments were designed to evaluate precision, detection limit, effective depth of analysis, and accuracy of X-ray fluorescence (XRF) arsenic readings. Results showed that the precision of the XRF improved with increased sample concentration and longer analysis times. Reported detection limits decreased with longer analysis times to values of less than 1 mg/kg or 18 mg/kg, depending on the model used. The effective depth of analysis was within the top 1.2 cm and 2.0 cm of sample for wood containing natural gradients of chemical preservative and concentration extremes, respectively. XRF results were found to be 1.5 to 2.3 times higher than measurements from traditional laboratory analysis. Equations can be developed to convert XRF values to results that are consistent with traditional laboratory testing.

Use of LIF, Hydroexcavation, and Temporary Retaining Structures for Precision Excavation Near an Active Mainline

Carney, S. (ERM); M. Woolridge and G. Jeffries (BNSF Railway).
2007 Railroad Environmental Conference, October 23-25, 2007: Presentation abstracts.
Illinois Railroad Engineering Program, p 18, 2007

A laser-induced fluorescence (LIF) investigation of diesel-contaminated soil showed an area of mobile nonaqueous-phase liquid (NAPL) measuring 300 feet by 75 feet located between an active main rail line and the yard office at an active railroad facility. LIF results were used successfully to define the limits of the mobile NAPL in the site investigation. The subsequent corrective action design specified excavation due to a high capillary bond of the NAPL to the silty-clay soils and a small radius of influence of other in situ remedies. Excavation limits were

selected and implemented on LIF results alone, and confirmed with diesel range organics (DRO) analysis. A temporary 720-ft retaining wall was constructed to complete the excavation. Hydro-excavation was used to remove approximately 36,000 gallons of soil and water to expose conflicting utility structures. Soil-type-specific NAPL saturation values from American Petroleum Institute Publication 1628 were used with existing DRO data to determine intervals with NAPL saturation. The NAPL saturation intervals then were compared with LIF responses to draw empirical estimates of mobile NAPL. An LIF response of 50% was proposed and approved by the regulating agency to serve as the threshold between soils with mobile NAPL (>50% response) and those with residual NAPL (<50% response). The excavation was successful in removing approximately 4,100 cubic yard of soil containing mobile NAPL without damage to property or safety incidents. The deepest extent of mobile NAPL occurrence varied between 7 and 14 feet bgs.

Use of Multi-Frequency Electromagnetic Profiling in a Remedial Investigation at Camp Kohler, McClellan Air Force Base

Allen, R.P. (Cabrera Services, Inc., East Hartford, CT); R.A. Crowson (Geo Solutions, Ltd., Raleigh, NC).

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 830-837, 2007

Camp Kohler, located one mile east of McClellan Air Force Base in Sacramento, CA, is a 35-acre site that was used as an internment camp for Japanese Americans during World War II. In 1947, an Air Force hospital on the premises was converted to a base laundry. Laundry operations ceased in 1973, and the building was demolished in 1982. Clothing contaminated with radioactive materials from radium painting operations and atmospheric testing at the Nevada Test Site was laundered at the Camp Kohler facility. Concerns regarding the release of radionuclides to the environment in and around Camp Kohler prompted the Air Force to conduct a remedial investigation (RI) to assess potential radiological releases. As part of this investigation, geophysical surveys were conducted to delineate possible disposal areas, potential underground storage tanks, and to verify the location of buried utilities. A multi-frequency electromagnetic (MFEM) survey was completed at Camp Kohler in the fall of 2005. Instrumentation consisted of a MFEM unit mounted on a plywood sled and towed behind an all-terrain vehicle. The MFEM unit was integrated with a GPS receiver. Ground penetrating radar (GPR) also was used to delineate electromagnetic anomalies. This paper details the logistics of the survey and the efficiencies achieved with rapid data collection along closely-spaced traverses. MFEM contour maps show the high level of detail that can be achieved with this technology.

Use of Passive Diffusion Samplers to Reduce Groundwater Sampling Costs and Improve Data Quality

McDermott, J. (Union Pacific); R. Kick (The Forrester Group, Inc.).

2007 Railroad Environmental Conference, October 23-25, 2007: Presentation abstracts.

Illinois Railroad Engineering Program, p 24 [poster abstract], 2007

Use of the passive diffusion bag (PDB) sampling technology, developed and patented by the U.S. Geological Survey, represents a simplified method by which ground-water samples can be collected from wells for analysis of volatile organic compounds (VOCs). Consisting of a low-density polyethylene (LDPE) tubular bag filled with laboratory-grade deionized water, the PDB is placed at a specified depth within the screen of a monitoring well. Over time, typically requiring a minimum of two weeks, VOCs diffuse from ground water through the LDPE membrane and into the water within the PDB sampler until chemical equilibrium is reached. The PDB is then removed from the well, and water is discharged through a tube or port into standard 40-milliliter sample containers. Subsequent sample management and analytical procedures are the same as for traditional sampling methods. Advantages of PDB samplers include reduced sampling time and cost compared to low-flow sampling; ease of deployment and retrieval; no purge water to dispose of; minimal need for equipment decontamination; good potential for determining vertical contaminant stratification in moderate- to high-permeability formations; no impact from turbidity or alkalinity-contributing solutes; and practicality for busy locations. Despite their many advantages, PDBs are not suitable for all VOCs or for natural attenuation parameters such as pH, temperature, redox, iron, and other ions. They also are not suitable for low permeability formations, formations with short temporal variations in ground-water chemistry, and wells with vertical flow. A case study from a recent railroad project illustrates the advantages of this sampling technique.

Use of Resistivity and IP as a Potential Screening Tool for Hydrocarbon Delineation in Highly Conductive Environments

Utne, J.I., Environmental Resources Management, Overland Park, KS.

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Philadelphia, PA. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 1063-1069, 2008

U.S. EPA's Triad approach was used at a former refinery complex to expedite the evaluation and subsequent redevelopment of the 13-acre brownfield property. The Geoprobe System soil conductivity/membrane interface probe (SC/MIP) and electrical resistivity imaging were selected as rapid screening tools to confirm the site conceptual model. These tools were combined with advanced data analysis techniques to develop a targeted soil and groundwater sampling program and to help decide upon a feasible remedial strategy. A resistivity survey identified lithologic changes, bedrock surfaces, and provided a graphical 3-D representation of the subsurface geology that was critical to the design of the SC/MIP subsurface investigation. Resistivity and induced polarization (IP) data were collected with a 48-electrode Syscal Pro Switch using a modified offset Wenner array designed for collection of high signal-to-noise measurements in conductive environments. Resistivity and IP data from the former refinery process areas indicated several anomalous areas that were consistent with the location of apparent underground refinery structures and associated hydrocarbon plumes. These results were confirmed with SC/MIP and subsequent soil and groundwater sampling programs. Results from

this study corroborate that resistivity and IP data can be used to expedite subsurface investigations and reduce costs associated with traditional investigation techniques.

Using Geophysics to Locate Unmarked Graves to Aid in Remediation Design and Construction at an NPL Site

Parish, Joseph, Tetra Tech EM Inc., St. Louis, MO.

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2008, Philadelphia, PA. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 399-405, 2008

A geophysical survey was conducted at the Rockwool Industries Superfund site to delineate the lateral extent of an old cemetery adjacent to a gulley where a culvert was to be constructed for remediation purposes. Several coffins in unmarked graves had been exposed by erosion, and the survey, which was conducted March 1 through 3 in 2005, was undertaken to avoid disturbing any other unmarked graves. The field crew employed a GSSI SIR 3000 ground penetrating radar system with a 400 MHz antenna and a GEM 2 terrain conductivity meter, initially running transects spaced 2.5 feet apart in an area measuring 25 feet by 40 feet over known grave sites to test the effectiveness of the equipment. Both the GPR depth sections and time-slice plots successfully identified six known grave sites and four unmarked graves, whereas the GEM 2 had only limited success. The results of the GPR survey identified four marked graves, but no additional unmarked graves were located. While the GEM 2 survey did not specifically identify individual graves, it did differentiate disturbed soil in the cemetery area from undisturbed soil, so it was used for a conservative delineation of the cemetery boundaries. The construction crew used the geophysical results to guide the placement of the culvert without incident.

<http://www.tetratech.com/StaticFile/PDFs/Papers%20&%20Articles/Using%20Geophysics%20to%20Locate%20Unmarked%20Graves.pdf>

Using Innovative Real-Time Field Analysis to Characterize a 1,4-Dioxane Plume in Wetlands Using the Triad Approach

Kiker, Jackson, Jeff Donovan, and Al Easterday, ECC; Michael Rossi and David Crosby, Stone Environmental, Inc.

International Conference and Training -- Triad Investigations: New Approaches and Innovative Strategies, June 10-12, 2008, University of Massachusetts Amherst. Program Abstracts, p 14, 2008

Owing to the detection of 1,4-dioxane, a previously defined plume of chlorinated volatile organic compounds (CVOCs) required re-characterization. Limited wetlands access and project economics required setting proper piezometer screen intervals using hollow-stem auger methods to intercept 1,4-dioxane during a single mobilization. The use of headspace solid-phase micro-extraction with gas chromatography/mass spectrometry (HS/SPME/GC/MS) supported expedited plume characterization. Using HS/SPME/GC/MS, the Henry's Law dynamic equilibrium between gas-phase and dissolved 1,4-dioxane is disturbed by irreversible 1,4-dioxane adsorption onto the SPME fiber. Following Le Chatlier's principle, there is a net transfer of 1,4-dioxane from solution to gas-phase, then SPME extraction, that results in higher extraction efficiencies compared to purge-and-trap methods. Although the stakeholders initially were skeptical, the use

of this innovative method in the field allowed for objective evaluation and management of uncertainty. A demonstration of method applicability was conducted in the field at the project site. U.S. EPA provided performance evaluation (PE) samples for analysis, and quality assurance (QA) samples were sent to an off-site Navy-certified laboratory. Following statistical evaluation of these PE and QA analyses, the technique was deemed acceptable for use. An adaptive sampling approach allowed for refinement of the conceptual site model, a more cost-effective plume characterization, and a single field mobilization.

Using Tree Core Samples to Monitor Natural Attenuation and Plume Distribution after a PCE Spill

Larsen, M. (Technical Univ. of Denmark, Kgs. Lyngby), J. Burken, J. Machackova, U.G. Karlson, and S. Trappt.

Environmental Science & Technology, Vol 42 No 5, p 1711-1717, 1 Mar 2008

In the area of a known plume with PCE concentrations between 0.004 and > 40 mg/L, cores were collected from tree trunks at a height of about 1 m above ground surface over a period of 6 hours. Chlorinated ethenes were analyzed by headspace GC/MS. PCE (0.001 to 7 mg/kg) and its natural attenuation products TCE (< 0.001 to 0.4 mg/kg) and c-DCE (< 0.001 to 0.46 mg/kg) were detected in the tree cores. 1,1-DCE and vinyl chloride were not detected, corresponding to very low concentrations in the groundwater. The contaminant plume was mapped from the concentrations measured in trees, which indicated a probable hot spot that had gone undetected in decades of traditional groundwater monitoring. Natural attenuation products in tree cores increased with distance from the known source area. Concentrations of PCE and reductive dechlorination products in tree cores were correlated with the corresponding groundwater concentrations. Within limitations, tree-core sampling provides a rapid, reliable, and inexpensive method to investigate the extent of shallow contamination by chlorinated ethenes in soil and groundwater.

<http://www.gbfl.de/biotools/Biotool/LarsenetalDTU-ISEB-2006.pdf>

Vertical Profiling Using the Color-Tec(r) Method to Identify Source Releases and Delineate CVOC Soil and Groundwater Plumes at the Former Naval Construction Battalion Center Davisville in North Kingstown, Rhode Island

Anderson, S. (Tetra Tech NUS, Inc.), J. Wright, L.A. Sinagoga, C. Frye, and D. Barney.

International Conference and Training -- Triad Investigations: New Approaches and Innovative Strategies, June 10-12, 2008, University of Massachusetts Amherst. Program Abstracts, p 15, 2008

Nearly 10 years of investigations, installation and sampling of ~200 wells, and other traditional investigative procedures (e.g., soil sampling, synoptic groundwater events, membrane interface probe (MIP) sampling, seismic refraction surveys) had only partially identified the sources and delineated the nature and extent of soil and groundwater CVOC impacts at Site 16 at the Former Naval Construction Battalion Center Davisville. To address significant data gaps, a comprehensive vertical profiling study employing the Color-Tec(r) method screening of soils from direct-push technology soil borings was performed across the site, beginning with an initial variably spaced coarse grid, with refinements made based on real-time data collection. Over 1,250 discrete soil samples were collected from approximately 150 soil borings. Discrete soil

samples were collected from continuous soil cores every 5 feet at most locations with more frequent soil samples collected based on observed lithologies and PID responses. The Color-Tec(r) results provided semi-quantitative results for immediate decisions for the subsequent placement of soil borings and the delineation of impacted/non-impacted areas. About 400 soil samples spanning the full range of Color-Tec(r) results were sent to a fixed-base laboratory. Comparison of these results to the Color-Tec(r) results demonstrated a significant site-specific correlation allowing for identification of source areas not identified previously and significant refinement to the lateral and vertical extent of the soil and groundwater plumes. Owing to the relatively low cost (\$10 per sample), the investigators were able to perform a comprehensive vertical profiling study in real time; significantly more soil samples could be analyzed compared to traditional fixed-base laboratory analyses, resulting in a better-defined understanding of the nature and extent of the CVOC plumes.

Wide Area Assessment of Munitions-Contaminated Sites

Nelson, H.H. (U.S. Naval Research Lab, Washington, DC); A.M. Andrews (SERDP/ESTCP Program Office, Arlington, VA).

SAGEEP 2007: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 1-5 April 2007, Denver, Colorado. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 255-263, 2007

The Environmental Security Technology Certification Program (ESTCP) initiated a Wide Area Assessment Pilot Program in 2005 for demonstrations on sites potentially contaminated with unexploded ordnance (UXO). These demonstrations followed a layered approach, with data being collected in different ways: (1) from high-flying aircraft using light detection and ranging (LiDAR) sensors for measuring variation in surface elevation and orthorectified photography, which are designed to detect anomalies that can be referred to as "munitions-related features"; (2) from low-flying helicopter-borne magnetometer arrays; and from ground arrays gathered using a vehicular-towed array of magnetometers and/or electromagnetic induction sensors where possible and a man-carried EMI sensor where terrain and vegetation dictate. The ground surveys are deployed in conjunction with statistical transect-planning surveying. These technologies, singly and in combination, are able to identify areas of concentrated munitions use, provide information as to the spatial extent and density of contamination in these areas, and most importantly, provide convincing evidence that portions of a site are not areas of concentrated munitions use and can be managed as such. These demonstrations have been conducted on sites that range from open desert to a firing fan in the Great Lakes. Depending on site conditions, a varying mix of technologies has been found to be appropriate, but at all sites, a combination of technologies has been required to maximize the information gained.

Wireless Sensor Networks in Geophysics

Charles Oden, Gary Olhoeft, Dan Jones, Stan Smith

SAGEEP 2008: Symposium for the Application of Geophysics to Environmental & Engineering Problems, 6-10 April 2007, Philadelphia, PA. Environmental and Engineering Geophysical Society, Denver, CO. CD-ROM, p 299-307, 2008

Today's wireless sensors, typically a few centimeters on a side, harvest their own power from their surroundings, remain in the field for long periods of time without servicing, and are

inexpensive enough to be considered disposable. Wireless sensors combine several recent technological advances: inexpensive miniature sensors, low-power radio telemetry, time synchronization techniques, localization techniques (spatial awareness), and energy-harvesting methods. Single-chip sensors are available for measuring electric, magnetic, and electromagnetic fields, temperature, pressure, mechanical displacement, chemistry, and attitude. These sensors can be used in a variety of geophysical methods, such as seismic, DC resistivity, induced polarization, EM induction, magnetometry, and ground penetrating radar. The small size of the sensors allows multiple types of measurements to be incorporated in a single sensor node. Wireless sensor network can be applied to investigations in ecology and environment, tracking of fluids or contaminant migration, vadose zone studies, and long-term monitoring and assessment of infrastructure. The authors review the capabilities and limitations of current wireless sensor network technology.

SBIR & OTHER GRANTS

National Institute of Environmental Health Sciences

Automatic Multi-Analyte In-Situ Bioassay for Monitoring Exposure to Toxic Metals (NIEHS 2008 SBIR Phase 2)

Grant Number: 5R43ES016458-02

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Kumetrix, Inc., Union City, CA

Project Start: 15-SEP-2007

Project End: 31-AUG-2009

The overall goal of the proposed work will be to develop a small, easy-to-use, handheld instrument used with disposable silicon microchips to provide rapid, in-field simultaneous detection of lead, cadmium, copper, and zinc in blood. The microsampling and assay chip, which integrates a microneedle comparable in size to a human hair for painless blood drawing with a microcuvette containing an electrochemical detection structure, can be fabricated cost-effectively using MEMS (microelectromechanical systems) technology. The assay will employ electrochemical-stripping analysis, a proven technique for accurate and precise detection of trace amounts of toxic heavy metals. The assay permits detection of the analytes without requiring sample de-oxygenation, and uses an internal standard to avoid the need for external calibration. It is thus ideal for field use and can be used by untrained personnel. In addition, self-metering of sample volume will provide for accurate determination of levels of the four metals in blood. Phase I will demonstrate feasibility by developing the assay and validating it with in vitro testing, designing the microchip and fabricating key components, and developing measurement and control instrumentation. In Phase II, a complete prototype system will be fabricated and evaluated via in vitro and animal testing.

Bacterial Diversity as a BioMarker of Soil Health (NIEHS 2008 Grant)

NIEHS Grant Number: 5R01ES015448-03

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University of Cincinnati, OH

Project Start: 01-AUG-2006

Project End: 31-MAY-2009

Because of their intimate association with soil contaminants, we hypothesize that the diversity (measured as richness and evenness) of the metabolically-active fraction of the soil bacterial community serves as a biomarker of the threat to human health from PAHs and heavy metals polluting Superfund sites. To challenge this hypothesis, we will address three specific aims: (1) Identify correlations between the results of molecular biology-based measures of bacterial diversity and analytical measures of PAHs and heavy metals during soil ageing and bioremediation of mock Superfund sites; (2) Demonstrate novel molecular biology-based assays to assess the diversity of the metabolically active fraction of the bacterial community in situ; and (3) Demonstrate ecological models to predict soil bacterial community diversity under the influence of mixtures of heavy metals and PAHs. The approach includes (i) operating mock Superfund sites; (ii) T-RFLP and (iii) whole cell FISH to measure bacterial diversity; (iv)

identifying predominant bacterial populations using clone libraries; (v) evaluating the impact of PAH and heavy metals on ribosome genesis; (vi) identifying heavy-metal responsive genes using microarrays; (vii) evaluating metagenomics of PAH degradation; (viii) evaluating real-time PCR to quantify heavy-metal and PAH-responsive genes; (ix) adapting ecological models to predict bacterial diversity; (x) comparing experimental measures of diversity with model predictions; and (xi) evaluating optimum nutrient amendments predicted with the resource-ratio theory. This project is innovative because we are using molecular biology-based measures of bacterial diversity as a diagnostic tool to predict the threat to human health at Superfund sites (i.e., bacteria as sentinels for pollution). We expect that the positive findings of this study can be used to evaluate the potential for success of bioremediation strategies as well as to establish an effective endpoint of bioremediation (i.e., when appropriate bacterial diversity has been re-established and the threat to human health significantly reduced).

Biocatalytic Air Monitor for Detection of Nerve Agents (NIEHS 2007 SBIR Phase 2)

NIEHS Grant Number: 5R44ES012763-03

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Nanodynamics Life Sciences, Inc., Pittsburgh, PA

Project Start: 14-SEP-2006

Project End: 31-AUG-2009

This Phase II SBIR proposal describes the development of a prototype device for monitoring the presence of hazardous chemicals in the air. This device is fundamentally different from typical spectroscopic instruments in that it uses enzyme-based plastics as sensing elements. Phase I showed that enzymatic plastics can be employed to continuously monitor the environment when properly adapted to a simple device. Agentase will adapt its proven enzyme-based chemistries for nerve, blood, and blister agent detection into forms that are compatible with continuous monitoring in the proposed Phase II effort. After optimizing individual sensors for sensitivity to agents and response time, a battery of experiments will be conducted to ensure that sensors have sufficient shelf life, operational lifetimes, and resistance to environmental interference. Custom built hardware will also be constructed to house the sensors and ensure their proper implementation. The work plan concludes with a series of operational assessments that serve as a true test of product feasibility prior to use in studies with warfare grade chemical agents. Successful completion of the effort will provide an inexpensive tool for monitoring air quality for the presence of hazardous chemicals. Once hardened and validated, such a device can be used to warn against an event of chemical terrorism. Early detection of released chemicals is the key to minimizing the impact of a chemical event on site and ensuring the best possible medical and emergency responses.

Catalytic DNA Biosensor for Toxic Metal Ions (NIEHS 2008 STTR Phase 2)

Grant Number: 2R42ES014125-02A2

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University of Illinois partnered with Dzymetech, Inc., Champaign, IL

Project Start: 05-SEP-2005

Project End: 31-MAR-2010

Cost-effective catalytic DNA biosensors for heavy metal ions such as lead(II), uranium(VI), mercury(II), and cadmium(II) will be developed. They will be tested for on-site, real-time detection and quantification with minimal rates of false positive or false negative results. The market for heavy metal detection is estimated to be >\$650 million. The project is based on several innovations in the PI's group at the University of Illinois that takes advantage of state-of-the-art tools in catalytic DNA biology, catalytic molecular beacons biotechnology, and nanoparticle nanotechnology. Catalytic DNA molecules specific for heavy metal ions will be obtained through in vitro selection and converted to fluorescent (for quantitative measurement) and colorimetric (for qualitative and semi-quantitative measurement) sensors by combining the DNA with fluorophore/quencher pairs and gold nanoparticles, respectively. The feasibility of transforming the innovations into commercial success at the DzymeTech has been established in the NIH STTR Phase I project (1R41ES014125-01), in which catalytic DNA sensors for lead(II) and uranium(VI) have been obtained that have high sensitivity (e.g., ~ 11 ppt) and selectivity (e.g., > 1 million fold). This Phase II application addresses critical issues of transferring the sensor design into prototypes of sensor kits for markets. The customer requirements will be determined and prototype components and protocols will be developed as follows. (1) Obtain all four fluorescent and colorimetric sensors for Pb(II), U(VI), Cd(II), and Hg(II). Characterize the sensors by determining the detection limit and selectivity of each sensor. (2) Design and characterize prototype sensor kits for each metal ion, including sensor components, storage condition and test protocol optimization, high/low temperature stability tests, and reproducibility tests with sensors from multiple-batches. (3) Test field samples to study interference and matrix effects. Real field samples, including soil and water samples will be collected and tested. Sensor performance with real samples will be used to evaluate the commercialization values of the sensor kits.

Detection of Environmental Agents Using a Novel Aerosol Sampler Coupled to a Micro-Particle Collector (NIEHS 2008 STTR Phase 2)

NIEHS Grant Number: 1R43ES016390-02

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Enertechnix, Inc., Maple Valley, WA, partnered with Micronics, Inc., and the University of Washington

Project Start: 24-SEP-2007

Project End: 31-AUG-2009

The proposed project will develop and demonstrate a personal exposure monitor that combines a novel aerosol concentrator, a micro-particle collector, and a microfluidic sample processing and detection platform customized to perform a broad range of assays, coupled to automated data recording and/or transmitting equipment and a position-monitoring device (such as a GPS unit) to provide time- and space-resolved measurements of a wide range of environmental agents. This exposure monitor will significantly improve the ability to localize

exposure events in space and time. The aerodynamic lens aerosol concentrator technology will be customized for use in a portable air sampler, integrated with a capillary aerosol particle collector, and interfaced to a microfluidics card where biological or chemical assays will be carried out and the results detected. Enertechnix, Inc. will be responsible for adapting its existing aerosol concentration and collection technology and Micronics, Inc. will adapt its commercial microfluidics card technology for use in a portable exposure monitor. The University of Washington will develop specific assays that can be adapted for implementation in the microfluidics environment for detection of target biological and chemical agents. Aerosol handling components will be developed by Enertechnix using engineering and CFD modeling capabilities previously developed for other Government-funded projects. These components will be tested using an existing, fully instrumented aerosol chamber and a variety of standard diagnostic methods for particle and bacterial detection such as epi-fluorescence microscopy, bulk fluorescence, culture, real-time PCR, etc. Microfluidic circuitry will be designed and prototyped by Micronics using methods and tools previously developed for production of similar microfluidic cards employing nucleic acid and immunological assays and electrochemical and other detection methods. Specific assays will be developed by the University of Washington using its expertise and laboratory facilities in the areas of microbiology, chemistry, environmental science (atmospheric pollutant detection and characterization), etc.

Development of a Selective Biosensor for Detecting Organophosphate Pesticide Exposure (NIEHS 2008 SBIR Phase 2)

Grant Number: 5R43ES016392-02

Jon O. Nagy, jon.nagy@nagyconsult.com

Ateris Technologies, LLC, Bozeman, MT

Project Start: 15-SEP-2007

Project End: 31-AUG-2009

This SBIR project is in response to the call for the development of field-deployable or wearable personal sensors for monitoring point-of-contact exposures to airborne chemicals through biosample testing. The broad objective of this proposal is to develop an extremely sensitive and selective biosensor device capable of detecting and discriminating proteins in human serum samples taken from patients suspected of being exposed to potentially harmful levels of organophosphate-based pesticides. This represents a novel approach in biomarker analysis because each organophosphate (OP) pesticide results in a distinct protein "fingerprint" structure that can be identified, distinguished from other agents and their conjugates, and quantified. Using ATERIS Technologies novel sensor thin polymer film technology, reporter domains will be customized with specific protein-recognition molecules that detect the OP poisoned proteins. This will make it possible to develop an inexpensive, yet highly rapid, sensitive, and accurate device to analyze exposure to OP pesticides, assess the type and extent of OP agent exposure and then this information will guide the therapeutic intervention necessary. The major milestones in the Phase I SBIR project are first to isolate biorecognition proteins capable of discriminating between native and OP-poisoned human proteins, then show proof-of-principal for the sensitivity and reliability of the film sensor element. In Phase II, the detection films will be incorporated into a reader device and the reproducibility and accuracy of detection of OP-modified proteins in actual serum samples will be determined. The data generated will guide the design of the commercial biosensor for OP pesticides and OP chemical agents.

Label-Free Immunoassay-Based Sensor Array for Assessment of Exposure to PAHs (NIEHS 2008 SBIR Phase 2)

Grant Number: 5R43ES016405-02

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Lynntech, Inc., College Station, TX

Project Start: 15-SEP-2007

Project End: 31-JUL-2009

Nanotechnology makes it possible to characterize chemical and mechanical properties at a single molecular level, discover novel phenomena and processes, and provide science with a wide range of tools, materials, devices, and systems with unique characteristics. The aim of this project is to develop a novel multiple biological sensor combining immunoassay (antibody-based detection) and emerging nanotechnology (a nanoscale biosensor) to assess real-time and continuous readout of internal exposure to priority environmental chemical agents, specifically to PAHs. In this innovative approach, the presence of targeted biomolecules in serum is monitored by specific antigen/antibody interaction at the nanoscale. Specific antigen/antibody interactions make this approach highly precise to identify specific antigens, such as biomarkers for PAH exposure, enabling accurate assessment of the exposure. Other advantages of this approach over conventional immunoassay techniques are (i) no other signal-generating moieties (labeling agents) are needed to measure the antigen/antibody interaction, (ii) multiplex assessment of informative and predictive serum biomarkers is possible, and (iii) wide range of applications. During the Phase I project, the proof-of-concept will be established, including the detection of antibody/antigen interactions in serum and in the presence of other biomarkers of other environmental exposure set. The proposed system has a high potential for user acceptance and has immediate commercial applications in many areas.

Low-Cost Electronic Nose for Groundwater Contaminants (NIEHS 2008 SBIR Phase 1)

Grant Number: 1R43ES016941-01

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Seacoast Science, Inc., Carlsbad, CA

Project Start: 01-SEP-2008

Project End: 28-FEB-2009

This project will result in the innovative use of low-cost sensor systems that will be capable of detecting and monitoring dense nonaqueous phase liquids (DNAPLs) in the subsurface and groundwater, unattended, and in real time from within a push-probe, using a chemicapacitor array and miniature preconcentrator. Seacoast's Phase I research will focus on developing the sensor array, demonstrating sensitivity to chlorinated hydrocarbons at relevant concentrations, and field tests in actual contaminated sites. The ultimate goal is to provide DoD, DOE, NIEHS, and other agencies with a method to map and track subsurface contamination plumes in real time without requiring an operator. The systems will have MEMS microcapacitor sensor arrays that can monitor for leaks of toxic chemicals, contaminants from wastes, and changes in groundwater streams. A preconcentrator collects the contaminants and releases them to a microsensor array. The sensor arrays are filled with several chemoselective polymers whose dielectric permittivity changes when exposed to different vapors, creating a fingerprint response

for each chemical. An array of differently responding sensors and pattern recognition can thereby compensate for changes in humidity, temperature, and composition. These low-power systems can be left unattended and transmit data wirelessly or through USB to a central location. The most important application to public health and safety is unattended monitoring of drinking water, water treatment processes, and water sources. The potential commercial markets include building chemical process monitoring and control, toxic vapor leak detection, industrial process control, and industrial health and safety.

Microchip-Based Perchlorate Analyzer for Water Remediation Monitoring and Field Analysis (NIEHS 2008 STTR Phase 1)

Grant Number: 1R43ES017200-01

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Colorado State University partnered with Advanced Microlabs, LLC, Fort Collins, CO

Project Start: 25-SEP-2008

Project End: 24-SEP-2009

This STTR Phase I project will develop a prototype online perchlorate monitor for a resin bed perchlorate remediation reactor. The device will have lower than a 4 ppb limit of detection, provide results in less than 3 min, and require only periodic microchip replacement as routine maintenance. Currently, perchlorate can be detected below 10 ppb only by using laboratory-based equipment requiring at least several hours of time, which is impractical for online monitoring. The Henry Group at Colorado State University has recently demonstrated sub-ppb perchlorate detection using a patent-pending lab-on-a-chip technology with results that include real water sample testing. This technology opens the door for online monitoring of perchlorate remediation operations, which will reduce the costs significantly. Entire resin beds costing \$100K in materials and additional costs in disposal would no longer be needed. This Phase I proposal will (1) develop pumps, valves, and instrumentation to assemble a field-deployable device, (2) optimize our microchip functions by incorporating a sample membrane barrier and assessing nonhazardous alternative internal standards, and (3) method validation and field testing.

A Microfluidic Biochip for Rapid Screening of Pesticide Residues (NIEHS 2008 SBIR Phase 1)

NIEHS Grant R43ES016704

Xiao-Li Su, PI

Biodetection Instruments, LLC, Fayetteville, AR

Project Start: 01-MAY-2008

Project End: 30-APR-2009

This SBIR Phase I project will develop an innovative biochip for rapid screening of pesticide residues in water and food samples. The proposed biochip will be built on BioDetection Instruments' exclusively-licensed patented technology and previous work on biosensors that are based on microfluidics, interdigitated microelectrodes (IMEs), and the electrochemical measurement of an indicator of microorganisms' physiological activity. An inexpensive and robust biomaterial that can sense the relevant bioactivity/toxicity of a class of widely-used pesticides will be immobilized onto the surface of an IME. A cover will be attached to the modified IME with a microfluidic channel exposed to the IME. Physiological activity of the

immobilized organism will be monitored in the absence and presence of atrazine, a model pesticide, by electrochemical measurement of the indicator, and the IME signal intensity is expected to be related to the pesticide concentration. One of the primary Phase I goals is to prove the concept by demonstrating the detection of atrazine in less than 10 min with a detection limit of 1 ppb (= 5 nM). The biochip will have the combined advantages of the biomaterial, microfluidics, and IME measurement such as low cost, high sensitivity, rapid speed, etc.. Contamination of water and food by pesticides and the potential hazard to human health remain major concerns of our society. Current pesticide detection methods such as HPLC, GC, and rapid test kits require sophisticated instruments, skilled personnel, extensive sample pretreatment, expensive bioreagents and/or intensive manual operations, and thus are unsuitable for on-site or routine screenings. Part of the challenge that faces the regulatory agencies and industries is to find better technologies for the rapid detection of low-level pesticide residues. Public Health Relevance: The proposed biochip technology will be a rapid and inexpensive method to screen drinking water, beverages, and food products on-site or on-line for the presence of pesticide residues. Using a network of screening tests followed by confirmatory analysis will assure both producers and consumers that these products are free of dangerous levels of pesticide residues and will enhance the protection and safety of the nation's water and food supply.

A Miniature Monitor for Time-Resolved Airborne Particle Chemistry (2008 SBIR Phase 2)

Grant Number: 2R44ES014997-02

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Aerosol Dynamics, Inc., Berkeley, CA

Project Start: 16-SEP-2006

Project End: 28-FEB-2010

A miniature, battery-powered monitor will be developed for measurement of hourly concentrations of chemical constituents of PM_{2.5} aerosols that are important to human exposure. The method utilizes a laminar-flow, water-condensation method to provide a concentrated, "ready-to-analyze" deposit of ambient particles. Many deposits will be contained on a single collection wafer designed for automatic analysis by common liquid chromatographic methods. The objective is wide-scale, inexpensive, time-resolved monitoring of individual constituents of ambient particulate matter for personal exposures assessment. This research improves the time-resolution and the range of chemical components that can be measured in personal monitoring studies.

Multiplexed Personal Monitoring of Airborne Toxins (NIEHS 2007 SBIR Phase 2)

NIEHS Grant Number: 5R43ES014977-02

Bharat R. Acharya, PI, Platypus Technologies, LLC, Madison, WI bacharya@platypustech.com

Project Start: 15-Sep-2006

Project End: 31-Jul-2009

Quantitative monitoring of personal exposure to environmental toxins is currently limited by expense, inconvenience, and lack of appropriate technology, yet such monitoring is needed for investigation of health effects caused by low dose, chronic exposure to compounds such as pesticides or industrial toxins. We have previously demonstrated that low concentrations of a semi-volatile organophosphate pesticide can be detected from a vapor phase by utilizing

chemically functionalized, nanostructured surfaces and liquid crystals (Platypus(r) technology). What is needed, however, is a monitor that simultaneously measures exposure to multiple compounds. In this proposal, we will demonstrate the feasibility of developing Platypus(r) technology for the quantitative and simultaneous detection of two different classes of semi-volatile pesticides (carbamates and organophosphates) and for the discrimination of specific compounds within each class of pesticide. The technology developed in this project can be adapted for detection of other industrial or environmental contaminants that are semi-volatile, and thus it has the potential to serve as the basis for a broadly useful, convenient, and inexpensive class of passive monitors for multi-compound personal exposure assessment and environmental monitoring. In this proposal, we are developing a small, inexpensive wearable device that will provide a measurement of an individual's exposure to multiple chemicals present in his environment over a period of a day to a few weeks. These data are essential for associating exposure to specific compounds with adverse affects on public health.

Novel Approaches to Studying the In Situ Bioremediation of Complex Mixtures (NIEHS 2008 Grant)

NIEHS Grant Number: 5R01ES015445-04

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Project Start: 28-SEP-2006

Project End: 31-JUL-2009

Although single pollutant/microorganism interactions can be determined easily in the lab, no satisfactory tools exist for predicting the fate of mixtures in the environment. The long-term goal of this project is to improve the success rate of bioremediation at sites containing complex chemical mixtures by using in situ microcosm array (ISMA) technology, a field-deployable, miniaturized laboratory consisting of a large number of small microcosms arranged in parallel. Upon deployment, incubation, and retrieval from a groundwater well, the ISMA can be analyzed to reveal the impact of mixture components on the rates of pollutant degradation and on the structure and function of microbial communities. The ISMA may aid in the design of bioremediation strategies because: (1) individual ISMA microcosms can be amended with multiple test substances to elucidate the effect of mixture components on microorganisms; (2) the response of microorganisms to presented compounds manifests itself as changes in biomass, community structure and function; and (3) these changes can be detected conveniently by biochemical, genetic and proteomic strategies. Based on the above observations, the specific aims of the project are as follows. (1) Determine the reproducibility and discriminatory power of the ISMA technology. We will explore how varying concentrations of inducers and co-contaminants in synthetic groundwater modulate the expression of the dioxin dioxygenase (DDase) of *Sphingomonas wittichii* Strain RW1, by using a large number of replicates in conjunction with semi-automated, high-throughput proteomic mass spectrometry. (2) Demonstrate in controlled laboratory conditions how the ISMA can reveal additive, synergistic, and antagonistic effects of mixture components on microbial communities. We will use defined mixtures of chemicals (e.g., dioxins, PCBs, PAHs, tolualdehyde, Cd, Cr, Co, Pb, Hg, Zn, Ni) and bacteria (five bioremediation agents) to study these effects in various permutations. (3) Evaluate the utility of the ISMA technology in simulated field conditions. We will conduct ISMA laboratory experiments using nonsterile groundwater, sediment, and natural microbial

communities. (4) Deploy the ISMA device at a Maryland Superfund site. We will assess the utility of the new technology in a field demonstration study by examining survival of and DDase expression by Strain RW1 in situ, and by elucidating the impact of this introduced bacterium on the indigenous microbial community at the site.

PAH Bioremediation and Monitoring in Biowalls (NIEHS 2008 Grant)

NIEHS Grant Number: 5R01ES015446-03

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Project Start: 01-AUG-2006

Project End: 31-MAY-2009

The overall goal of this research is to gain an understanding of the transport and biodegradation mechanisms of complex mixtures of toxic pollutants (i.e., PAHs and heavy metals such as arsenic and cadmium) at Superfund sites. Determining the role of biofilm in biowall or permeable bio-barrier systems is crucial to the design of more efficient treatment systems because the mass transport mechanisms, structural forms, and biodegradation processes in soil biofilms are not well understood. The engineering component will focus on design and evaluation of mulch-based biowalls and development of pollutant monitoring microelectrodes for application in studying the biodegradation of PAH/metal mixtures in groundwater at Superfund sites. The potential use of fungi in the biowall will be examined. Research will be conducted in a simulated Superfund testbed that replicates a contaminated groundwater system. The successful monitoring of biofilms and pore water at Superfund sites will also improve process efficiency in bioremediation treatment. Therefore, microelectrodes developed in previous SBRP research will be modified for field use and used in the testbeds. In addition, a new MEMS-based heavy metal analyzer for use in the field will be developed. The result of this research will be a better understanding of bioremediation potential for complex mixtures of toxic materials at Superfund sites.

Portable Arsenic Monitor For Drinking Water (NIEHS 2008 SBIR Phase 2)

Grant Number: 5R44ES011913-03

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Eltron Research, Inc., Boulder, CO

Project Start: 01-SEP-2003

Project End: 31-JUL-2009

The goal of this Phase II program is develop, test, and produce a prototype field analytical instrument for electrochemical monitoring of arsenic in drinking water. This program seeks to provide a new avenue to laboratory-quality arsenic detection and quantification in a field-portable device at reasonable cost. Specific Aims of the Phase II program will include design and construction of a prototype field-portable analytical system for detection of arsenic in drinking water at concentrations between sub-ppb and many ppm. The performance of the instrument will be characterized in the lab for the effects of real sample issues, including several classes of interferences and environmental variables. Once fully characterized, the prototype will be tested in the field with selected stakeholders in the drinking water distribution system arena. The new prototype technology will be benchmarked against standard analytical laboratory

methods and other available field tests, such as colorimetric kits. During Phase I, favorable comparison to standard analytical laboratory analysis has already been obtained on drinking water samples from New Mexico and remediation treatment process water from Nevada. These results provide high confidence that the proposed analytical methodology will be an effective tool to prevent arsenic related disease from drinking water exposure. In the United States and globally, contamination of drinking water by naturally occurring arsenic puts populations at risk of a variety of arsenic-related diseases. The proposed Phase II program will provide a cost-effective and highly accurate way to monitor arsenic in drinking water at the site of the water source. The long-term vision for this technology is that it will become a useful tool for helping to arsenic-related disease among exposed populations.

Portable Pesticide Monitor (NIEHS 2008 SBIR Phase 2)

NIEHS Grant Number: 5R43ES016397-02

Tony J. Ragucci, tony.ragucci@lynntech.com

Lynntech, Inc., College Station, TX

Project Start: 15-SEP-2007

Project End: 31-JUL-2009

Pesticides pose a significant health hazard to the general public and especially individuals working or living around farmland. Pesticides can enter the drinking water supply via run-off into lakes and streams. To help prevent exposure to these toxic compounds, Lynntech proposes to develop a wearable/portable sensor that can detect, identify and determine the concentration of these compounds within a variety of matrices, i.e., air, water, and/or soil in a rugged and reliable device. Using cutting-edge nanotechnology, Lynntech will fabricate miniaturized sensors coupled with innovative enzyme matrices that have the potential to identify P-O, P-S, and P-F type pesticides individually, providing an improved sensing platform for critiquing their source. The proposed sensor technology will be extremely lightweight and long-lasting due to its low power requirement, small size, and enhanced enzyme stabilization. The proposed pesticide sensor will have commercial applications in both remote and/or point-of-use monitoring all water supplies, protecting farmers/crop-sprayers or military soldiers in the battlefield against chemical warfare agents which are often in the form detectable by the proposed sensor. Lynntech's Phase I research will consist of several proof-of-concept experiments which will involve the demonstration and characterization/optimization of the signal response's sensitivity, selectivity and propensity to give false-positive responses. Phase II research will continue with the advancement of the sensing platform with the design, assembly and testing of the first-generation wearable sensor with automated sampling, processing, and data display.

Project 5: Nanotechnology-Based Environmental Sensing (NIEHS 2008 Grant)

Catherine P. Koshland, PI, ckosh@uclink2.berkeley.edu

University of California Berkeley

Project Start: 2008

Project End: NA

We have developed methods to produce novel nanoparticles, arrays, and structures that could be used for chemical analysis, and propose several approaches that combine evolving methods with the characterization and monitoring needs of Superfund. They are linked by their

use of small-scale properties to develop new methods that should be faster, easier, smaller, and/or less expensive. The technologies on which we will focus ultimately could lead to a number of nanometer-based devices that are portable and robust and can be employed at commercial facilities or in the field for environmental monitoring. Our specific aims are to (1) develop low-cost sensors and sensor arrays for measuring chemical species such as arsenic and mercury using nanoparticle properties that can be probed optically and electronically, (2) develop methods to identify biomolecules (specific antibodies/antigens used in bioremediation) by probing their unique local electronic structure using electron tunneling, and (3) investigate the use of new manufactured nanostructured materials for molecular detection, including structures such as carbon nanotubes and coated nanoparticles. The aims are divided into four tasks: (i) gas phase detection of heavy metals using nanoparticle complexes with laser fragmentation spectroscopy, (ii) mercury detection with gold nanoparticles, (iii) surface-enhanced raman spectroscopy detection of arsenic species, and (iv) the detection of bioremediation organisms using electronic cell typing. This project will investigate using the different and sometimes unique behavior of materials as their size shrinks below 100 nm to develop new methods to detect chemical and biological species found at existing or potential Superfund sites.

A Rapid Label-Free Sensor for Immune Markers of Environmental Exposure (NIEHS 2008 SBIR Phase 1)

NIEHS Grant 1R43ES016406-01S1

Christopher Striemer, striemer@ece.rochester.edu

Pathologics, LLC, West Henrietta, NY

Project start date: 2007-09-24

Project end date: 2008-08-31

Pathologics seeks to leverage its proprietary Arrayed Imaging Reflectometry (AIR) biosensing platform to build a device capable of capturing the detailed physiological response to airborne particulate matter (PM) exposure by profiling key marker proteins in conveniently available biosamples such as a finger pick of blood, urine, mucous, saliva, etc. Currently, such testing takes hours and is often done with individual tests. AIR is capable of sensitive and simultaneous protein detection with a device that is currently the size of a laptop computer. The low complexity of the testing platform will also enable the development of handheld units that would be particularly useful for profiling exposure response in the field. In addition to saving time and offering greater convenience these multiplex sensors will allow far more molecular data to be collected than is currently feasible

Rapid, Miniaturized Sensors to Detect Environmental Toxins (NIEHS 2008 Grant)

Grant Number: 5P42ES004699-220016

Ian M. Kennedy, PI

University of California, Davis

Project Start: 2008

Project End: NA

This biosensor project aims to implement previously developed bioassays into usable biosensors. The fundamental aspects will investigate new nanoscale materials for bio-labeling. Long-lived nanoscale phosphors have been found to be particularly useful for labeling haptens,

analytes, or antibodies in an immunoassay. We will focus on the use of the lanthanide elements, in particular europium, plus other wavelengths that can be offered by materials such as terbium oxide. We also will investigate a novel format for carrying out immunoassays in a microdroplet. Samples that contain picoliters can be interrogated for a very long times with our photobleaching labels, with the potential for approaching single-molecule detection limits in assays. The more practical aspect of the project will be concerned with implementing existing assays in miniaturized biosensors on a chip. We will make use of microfabrication techniques to make microchannels on a chip to carry out the immunoassays. We will make use of indium tin oxide (ITO) films as waveguides and as electrodes to manipulate nanoparticles labels and antibodies in channels. We will use evanescent detection of the particle labels within the channel, and use an electrostatic field to enhance binding to antibodies and potentially to regenerate antibodies within the channel. We also will attempt to improve the detection of DNA for sampling in soils to assist Project 1 in their measurements of toxin-consuming bacteria within soils. The biosensor project will implement an in vitro assay for dioxin for use in Dr. Denison's project and will work with Dr. Lasley's project to implement a miniaturized, portable biosensor for markers of reproductive health.

Rapid Pesticide Exposure Analysis Using Surface-Enhanced Raman Spectroscopy (NIEHS 2008 SBIR Phase 2)

Grant Number: 5R43ES016409-02

Kevin M. Spencer, spencer@eiclabs.com

EIC Laboratories, Inc., Norwood, MA

Project Start: 15-SEP-2007

Project End: 31-JUL-2009

An inexpensive disposable sensing element that is worn as a vapor exposure monitor or used for urinalysis is proposed for real-time monitoring of pesticide exposure. This sensor, coupled to a battery operated reader, is a direct need for the NIH Exposure Biology Program and has the potential for detecting other exposures as well. The sensor is based on surface-enhanced raman spectroscopy (SERS), which allows precise detection of chemicals that adsorb strongly to roughened SERS sensors, like pesticides, into the high ppt range. The SERS sensors, which are vapor-deposited gold films with subsequent electrochemical roughening, are inexpensive to make and can operate in vapor phase under a wide humidity range and in solution. Because the sensors are tuned to the analytes of interest, interferences from more concentrated chemicals is limited. In this program, the SERS sensors would be worn as badges to monitor and quantify daily pesticide exposure to a worker by irreversibly binding any pesticide that comes in contact with the SERS sensor. The sensors would also measure pesticide metabolites in urine, providing the NIH with more data on the daily exposure/daily ingestion of pesticides. The SERS sensors will be read using a battery-operated Raman instrument with keyed sampling chamber that ensures the SERS sensing elements are automatically aligned into the system. The compact system would be fully automated and incorporate a spectral library with chemometric analysis. Identification and quantification of any detected pesticides would be reported to the field technician. A single reader can be used for evaluation of hundreds of participants. The core concepts of this technology have been developed and demonstrated. Literature results show SERS detection of organochlorine pesticides, and EIC Laboratories has detected organophosphate pesticides in vapor and aqueous phases. Field detection of trace levels of

explosives also has been demonstrated by EIC Laboratories. The two-year Phase I program is designed to expand the pesticides studied, demonstrate detection to CDC listed limits, show an adequate usable field lifetime for the SERS sensing elements, design a fieldable reader, perform a detailed interferences analysis, and demonstrate that variances in the urine matrix will not affect the SERS measurement precision. EIC Laboratories will commercialize the technology by manufacturing the SERS sensors and battery operated Raman readers. The components will be sold commercially through In Photonics, an affiliated company under common ownership.

Real Time Monitoring of Environmental Exposure to Pesticides (NIEHS 2008 SBIR Phase 2)

Grant Number: 5R43ES016410-02

Kumar Subramanian, kumar@phoenixbiosystem.com

Phoenix Biosystems, Inc., Pleasanton, CA

Project Start: 21-SEP-2007

Project End: 31-AUG-2009

Phoenix Biosystems intends to leverage the in-house expertise in sensors, microfluidics, and microelectronics to design, develop, and validate novel battery-powered portable measurement technologies that (by the end of the Phase II funding period) will result in field-deployable tools to provide accurate internal assessment of internal dose and/or activity of priority environmental exposures in real time. The sensors would have the ability to measure multiple agents within a single class of exposure (i.e., pesticides). The Phase I prototype will detect personal exposure to OP conjugates in whole blood samples. Since the resultant OP conjugate typically correlates directly with the OP structure, an antibody-based nanoarray analysis would be superior to the current, end point-based colorimetric method.

Separation of Sr-90 and Ca²⁺ in Environmental Samples (NIEHS 2007 SBIR Phase 2)

Grant Number: 5R44ES013051-03

Alan J. Cisar, PI, renee.hisaw@lynntech.com

Lynntech, Inc., College Station, TX

Project Start: 01-JUL-2006

Project End: 30-JUN-2009

The goal of this SBIR project is the development of an improved inorganic ion exchanger with an extremely high selectivity for Sr²⁺. This ion exchanger will improve the extraction of Sr-90 from groundwater that have become contaminated through mishap or poor handling of nuclear materials, some of which are in contact with bodies of water used as drinking water supplies. Sr-90 is an isotope with an extremely low maximum safe exposure limit. (The drinking water limit is 8 pCi/L.) Development of this material will make a significant contribution to safer drinking water. In Phase I of this project we demonstrated that the substitution of SnIV and SiIV for part of the SbV in the pyrochlore-structured antimonite acid (Sb₂O₅ · 4 H₂O) increased both the compound's affinity for Sr²⁺ and its selectivity for strontium over calcium by a factor of nearly four. (A strong preference for Sr²⁺ is important, because the strontium is always found with a large excess of calcium.) The resulting material has a capacity for Sr-90 over 200 times that of the clinoptilolite currently used to collect strontium in pump-and-treat systems. In Phase II we will refine the composition of the exchanger and scale up the synthesis. The material will be evaluated in complete detail for use as a column material for extracting Sr-90 from

groundwater as the active component in a permeable reactive barrier to block the flow of Sr-90 in groundwater. In plain language: Adding tin or silicon to antimonite acid greatly improves its ability to remove strontium from aqueous solutions in the presence of the very similar calcium. This makes it an excellent choice for removing radioactive strontium-90 from ground water either at the surface, or while still in the ground.

Wearable Photoelectrocatalytic Personal Environmental Exposure Monitor (NIEHS 2008 STTR Phase 1)

Grant Number: 3R43ES016400-01S1

Steven Leboeuf, PI, leboeuf@valencell.com

Valencell, Inc., Raleigh, NC, partnered with North Carolina State University

Project Start: 30-SEP-2007

Project End: 31-AUG-2009

Valencell's long-term goal is to provide a noninvasive, low-profile, real-time, affordable personal environmental exposure monitor platform that is virtually unnoticed by the user for maximum performance and convenience. The specific goal of this Phase I feasibility study is the development of a novel sensor element providing the flexibility of monitoring volatile organic compounds (VOCs), ozone, carbon monoxide, polycyclic aromatic hydrocarbons (PAHs), and other reactive airborne species in the same compact device. Filament-heated tin oxide VOC sensors, the workhorse of solid-state VOC sensing, are sufficiently compact but require significant operating power and lack vapor specificity. Valencell's innovative approach is the development of a novel wide band gap (WBG) VOC sensor offering enhanced vapor specificity and dramatically reduced power consumption over standard metal oxide sensors. This innovation enables the development of a novel, low-power (<10 mW), real-time (<100 ms sampling), compact (< 10 cm³), wearable VOC monitor capable of long-term battery-powered operation, high specificity, and broad sensitivity (0.1 to 1000 ppm). In this program, Valencell will fabricate sensor electrodes from novel WBG metal-oxide films deposited by North Carolina State University (NCSU). The functionality of these sensor electrodes will then be validated by evaluating the sensitivity and specificity of each electrode in a bell jar VOC test bed. The sensor electrodes will then be integrated into a self-contained VOC sensor prototype such that the predicted performance specifications can be statistically validated in the VOC test bed.

A Wearable Wireless System for Real-Time Monitoring of Chemical Toxicants (NIEHS 2008 Grant)

NIEHS Grant Number: 5U01ES016064-02

Nongjian Tao, nongjian.tao@asu.edu

Arizona State Univ., Tempe

Project Start: 15-AUG-2007

Project End: 31-MAY-2011

This project brings together a joint effort involving chemical sensor researchers at Arizona State University (ASU), toxicologists at University of Arizona, R&D scientists and engineers at Motorola, and field testing experts at Arizona Division of Occupational Safety & Health to build, validate and test a powerful wearable sensing system. The sensor technology is built upon a novel microfabricated tuning fork array sensor platform invented at ASU and

wireless sensor technology developed at Motorola. The project will leverage on the expertise and resources gathered for an on-going collaborative R&D effort on wireless chemical sensors between the ASU and Motorola team. The goal is not only a wearable sensor system for quick, accurate and reliable detection of chemical toxicants, but also an affordable, easy-to-upgrade and user friendly product for population studies.

U.S. DoD: Environmental Security Technology Certification Program

Application of Advanced Sensor Technology to DoD Soil Vapor Intrusion Problems (ESTCP 2007 Grant)

Project ER-0702

Dr. Rob Hinchee, PI, 850-984-4460, rob@hinchee.org

IST Inc., Panacea, FL

2007 Start: Anticipated Project Completion - 2010

Objectives: Screen available advanced sensor technologies, select those most promising, and build and demonstrate sensor packages for the following applications: (1) a portable "sniffer" unit for near real-time, compound-specific determination in support of contaminant source assessment; (2) a fixed "smoke detector" unit for compound-specific exposure concentrations interfaced with remote communications; and (3) an in-line pressure unit for subslab depressurization system long-term performance monitoring interfaced with remote communications.

<http://www.estcp.org/Technology/ER-0702-Fact-Sheet.cfm>

Demonstration and Validation of a Fractured Rock Passive Flux Meter (ESTCP 2008 Grant)

ESTCP Project ER-0831

Kirk Hatfield, PI, 352-392-9537 Ext. 1441, khatf@ce.ufl.edu

University of Florida, Gainesville

2008 Start: Anticipated Project Completion - 2011

Complex hydrogeologic conditions such as fractured and karst bedrock settings pose substantial economic and technical challenges both to the characterization and remediation of DNAPL source zones. Objective: Demonstrate and validate the fractured rock passive flux meter (FRPFM) as a new technology that measures the magnitudes and directions of cumulative water and contaminant fluxes in fractured rock aquifers.

<http://www.estcp.org/Technology/ER-0831-FS.cfm>

Demonstration/Validation of the Snap Sampler Passive Groundwater Sampling Device (ESTCP 2006 Grant)

ESTCP Project ER-0630

Ms. Louise Parker, PI, 603-646-4393, Louise.V.Parker@erdc.usace.army.mil

U.S. Army Corps of Engineers, ERDC/CRREL, Hanover, NH.

2006 Start: Anticipated Project Completion - 2009

Objective: Demonstrate that passive (no-purge) groundwater sampling technology and the relatively newly developed Snap Sampler can provide technically defensible analytical data

for the wide spectrum of analytes that are of concern to DoD and can generate substantial cost savings.

<http://www.estcp.org/Technology/ER-0630-FS.cfm>

The Determination of Sediment Polycyclic Aromatic Hydrocarbon (PAH) Bioavailability using Direct Pore Water Analysis by Solid-Phase Microextraction (SPME) (ESTCP 2007 Grant)
ESTCP Project ER-0709

Dr. David Nakles, PI, 412-380-0140, Ext. 225, dnakles@ensr.aecom.com

The RETEC Group, Inc., Monroeville, PA

2007 Start: Anticipated Project Completion - 2009

Objectives: (1) Use supercritical fluid extraction and ultra-trace porewater analyses to estimate the bioavailability of PAHs in marine/estuarine sediments collected from two DoD facilities, (2) Compare the predicted toxicity of the impacted sediments using these bioavailability data and the EPA narcosis model to the actual measured toxicity of the sediment to a macroinvertebrate, and (3) Develop technical and regulatory guidance for the management of PAH-impacted sediments, guidance that incorporates use of the supercritical fluid extraction and ultra-trace porewater site-specific estimates of PAH bioavailability for predicting toxicity.

<http://www.estcp.org/Technology/ER-0709-FS.cfm>

Development of More Cost-Effective Methods for Long-Term Monitoring of Soil Vapor Intrusion to Indoor Air Using Quantitative Passive Diffusive-Adsorptive Sampling Techniques (ESTCP 2008 Grant)

ESTCP Project ER-0830

Todd McAlary, PI, 519-822-2230 Ext. 239, tmcalary@geosyntec.com

Geosyntec Consultants, Inc., Guelph, ON

2008 Start: Anticipated Project Completion - 2011

The most common method for vapor intrusion assessment is EPA Method TO-15; however, passive sampling techniques would greatly reduce costs for both sampling and analysis. This project will demonstrate the applicability of passive-diffusive samplers as lower-cost alternatives for sampling and analysis of VOCs in indoor air and soil gas during investigation of subsurface vapor intrusion into indoor air. The results of this work will provide a comparative study of diffusive gas sampling techniques to identify under which conditions the passive samplers provide good quality data that will be accepted by regulatory agencies.

<http://www.estcp.org/Technology/ER-0830-FS.cfm>

Field Validation of the Digital Opacity Compliance System (DOCS) for Fugitive Emissions Monitoring (ESTCP 2006 Grant)

ESTCP Project SI-0612

Steve Rasmussen, PI, 801-514-5385, steve.rasmussen@hill.af.mil

Ogden Air Logistics Center, Hill Air Force Base, UT

2006 Start: Anticipated Project Completion - 2009

Objective: Evaluate performance of the digital opacity compliance system (DOCS) for quantifying the regulatory enforceable fugitive emission opacity levels.

<http://www.estcp.org/Technology/SI-0612-FS.cfm>

Geophysical Imaging for Investigating the Delivery and Distribution of Amendments in the Heterogeneous Subsurface of the F.E. Warren AFB (ESTCP 2008 Grant)

ESTCP Project ER-0834

Robert Kelley, PI, 815-230-3516, bkelley@regenesis.com

Regenesis, Plainfield, IL

2008 Start: Anticipated Project Completion - 2010

The proposed work will show how geophysical imaging can be used to verify the placement and subsurface distribution of amendments to treat contaminants in the subsurface. Through coupled laboratory and field experimentation followed by a cost/benefit analysis, the work will assess the utility of time-lapse geophysical methods and geophysical datasets for monitoring and detecting fracture and amendment distribution, the utility of geophysical methods to monitor amendment diffusion rates, and the cost effectiveness of geophysical methods for developing and validating an amendment delivery strategy compared to conventional approaches. <http://www.estcp.org/Technology/ER-0834-FS.cfm>

Improved Field Evaluation of NAPL Dissolution and Source Longevity (ESTCP 2008 Grant)

ESTCP Project ER-0833

Michael Kavanaugh, PI, 510-735-3010, mkavanaugh@pirnie.com

Malcolm Pirnie, Inc., Emeryville, CA

2008 Start: Anticipated Project Completion - 2009

Objective: Measure non-aqueous phase liquid (NAPL) mass flux in the source zone with novel tools, including integral pumping tests combined with the deployment of passive flux meters and multi-component modeling using the source zone depletion function of SEAM3D (Sequential Electron Acceptor Model, 3D). The results will be generalized to improve the characterization of NAPL mass, distribution, and the projected longevity of NAPL source areas, as well as to assess the potential costs and benefits of partial source reduction.

<http://www.estcp.org/Technology/ER-0833-FS.cfm>

Integrated Forensics Approach to Fingerprint PCB Sources Using Rapid Screening Characterization and Advanced Chemical Fingerprinting (ESTCP 2008 Grant)

ESTCP Project ER-0826

James Leather, 619-553-6240, leather@spawar.navy.mil

SPAWAR Systems Center, San Diego, CA

2008 Start: Anticipated Project Completion - 2011

Objective: Provide guidance on integrating chemical techniques into a cost-effective forensics program to apportion regulatory costs among PRPs. The technology to be demonstrated includes two primary components: 1) screening technologies that provide for wide spatial and temporal coverage to delineate sediment contaminant heterogeneity in a cost effective manner; and 2) advanced chemical fingerprinting on a selected subset of samples to delineate sources.

<http://www.estcp.org/Technology/ER-0826-FS.cfm>

Monitored Natural Attenuation of Explosives in Groundwater Using Stable Isotope Ratio Analysis (ESTCP 2007 Grant)

ESTCP Project ER-0706

Dr. Farrukh Ahmad, 713-522-6300, fahmad@gsi-net.com

GSI Environmental, Inc., Houston, TX

2007 Start: Anticipated Project Completion - 2010

This project aims to bolster the existing ESTCP monitored natural attenuation (MNA) protocol, specifically for sites with explosives-contaminated groundwater. To this end, a robust demonstration/validation of a tertiary line of evidence for MNA will be conducted, and a practical software decision tool for screening sites for the potential application of MNA remedies will be developed. The tertiary line of evidence will help distinguish groundwater plumes where true mass removal processes are occurring from plumes where nontransformative physical processes dominate.

<http://www.estcp.org/Technology/ER-0706-Fact-Sheet.cfm>

Protocol for Tier 2 Evaluation of Vapor Intrusion at Corrective Action Sites (ESTCP 2007 Grant)

ESTCP Project ER-0707

Dr. Thomas McHugh, 713-522-6300, temchugh@gsi-net.com

GSI Environmental Inc., Houston, TX

2007 Start: Anticipated Project Completion - 2011

Investigators will develop and validate Tier 2 procedures for screening vapor intrusion at corrective action sites along with exit criteria indicating no further need for site evaluation. These procedures will use easily obtainable site-specific information to support the application of screening concentrations that are less conservative than the Tier 1 screening concentrations provided in U.S. EPA and many state vapor intrusion guidance documents. The Tier 2 procedures will fill the current gap in available guidance documents between generic (Tier 1) screening concentrations and detailed site investigations of vapor intrusion.

<http://www.estcp.org/Technology/ER-0707-FS.cfm>

Use of Enzyme Probes for Estimation of Trichloroethene Degradation Rates and Acceptance of Monitored Natural Attenuation (ESTCP 2007 Grant)

ESTCP Project ER-0708

Dr. Michelle Lee, 208-557-7820, hlee@northwind-inc.com

North Wind Inc., Idaho Falls, ID

2007 Start: Anticipated Project Completion - 2009

Enzyme probes have the potential to be used as practical tools for quickly and conclusively determining the potential for biologically mediated degradation and accurately estimating degradation rates. The objective of this project is to demonstrate the relationship between enzyme activity probes and contaminant degradation rates. Specific objectives include: (1) determine the importance of natural attenuation mechanisms at 2 DoD sites by combining a suite of innovative techniques to provide a comprehensive assessment of active degradation mechanisms, and (2) determine a biological degradation rate for TCE based on laboratory

microcosms and normalize this rate based on enzyme probe activity, such that a realistic rate for the field can be obtained for the chlorinated solvent-contaminated sites.

<http://www.estcp.org/Technology/ER-0708-Fact-Sheet.cfm>

Verification of Methods for Assessing the Sustainability of Monitored Natural Attenuation (ESTCP 2008 Grant)

ESTCP Project ER-0824

Carmen Lebrón, 805-982-1616, carmen.lebron@navy.mil

NFESC, Port Hueneme, CA

2008 Start: Anticipated Project Completion - 2011

This project will demonstrate/validate a framework and methods as well as provide an interactive computational tool to assess the long-term sustainability of MNA-based remediation strategies. Objectives: (1) Validate a methodology for calculating bioavailable organic carbon (BOC) by establishing correlations with field-measured dissolved oxygen (DO) and chloroethene concentrations, concentrations of natural organic carbon compounds present in aquifer sediment, and rate and extent of reductive dechlorination; (2) Verify the upscaled source zone depletion (SZD) function using site contaminant concentration data for a range of source zone geometries; and (3) Validate short term sustainability using BOC and DO concentration data and demonstrate long term sustainability of MNA using SEAM3D v.2.1 at four sites where time of remediation is estimated using the SZD function.

<http://www.estcp.org/Technology/ER-0824-FS.cfm>

U.S. DoD: Strategic Environmental Research and Development Program

An Enzymatic Bioassay for Perchlorate (SERDP 2006 Grant)

SERDP Project ER-1530

Dr. John Coates, 510-643-8455, jcoates@nature.berkeley.edu

University of California, Berkeley

2006 Start: Anticipated Project Completion – 2010

Objective: Develop a highly sensitive and specific analytical colorimetric assay for the rapid determination of perchlorate in environmental samples. Once developed and optimized, the bioassay will be able to be applied with the minimum of training, will not require specialized expensive laboratory equipment, and may be adapted for handheld field fluorometers and spectrophotometers. The assay can be mass-produced and will allow perchlorate contamination to be rapidly identified.

Principal Investigator: <http://www.serdp.org/Research/upload/ER-1530.pdf>

Metal Ion Sensor with Catalytic DNA in a Nanofluidic Intelligent Processor (SERDP 2005 Grant)

SERDP Project CS-1459

Dr. Donald Cropek, 800-872-2375 Ext. 6737, donald.m.cropek@erdc.usace.army.mil

U.S. Army Corps of Engineers, ERDC/CERL, Champaign, IL

2005 Start: Anticipated Project Completion - 2008

Objective: Develop a prototype highly selective and sensitive miniaturized sensor for lead by combining two recent advances: (1) catalytic deoxyribonucleic acid (DNA) that is reactive only to lead and can be tagged to produce fluorescence and (2) nanoscale fluidic molecular gates that can manipulate fluid flow and perform molecular separations on tiny volumes. http://www.serdp.org/Research/upload/CS_FS_1459.pdf

Micro Ion Mobility Sensor for In Situ Monitoring of Contaminated Groundwater (SERDP 2008 Grant)

SERDP Project ER-1603

Dr. Jun Xu, PI, 865-574-8955, xuj2@ornl.gov

Oak Ridge National Laboratory, Oak Ridge, TN

2008 Start: Anticipated Project Completion - 2011

Objective: Adapt a technology (currently used at airport security checkpoints for rapid screening for trace explosives and at battlefields for detecting trace chemical warfare agents) to enable long-term, real-time monitoring of groundwater contaminants (e.g., chlorinated hydrocarbons). Specific challenges include reducing interference in hostile environments, achieving high identification power, and effectively converting liquid sample to vapor phase. <http://www.serdp.org/Research/upload/ER-1603.pdf>

Novel Sensor for Real-Time Characterization and Monitoring of Chlorinated Hydrocarbons in Groundwater (SERDP 2008 Grant)

SERDP Project ER-1605

Bill Major, PI, 805-982-1808, william.major@navy.mil

NFESC, Port Hueneme, CA

2008 Start: Anticipated Project Completion - 2011

Objective: Develop and optimize a novel, real-time sensor technology to discriminate and quantify PCE, TCE, cis- and trans-DCE, and VC in groundwater. Independently, Georgia Tech Research Institute (GTRI) and American Research Corporation of Virginia (ARCOVA) have developed sensors that use polymers deposited on a glass slide to select and concentrate contaminants reversibly in groundwater or air as samples pass through the sensor. Both sensors use a diode laser positioned to elicit total internal reflectance, which generates an evanescent wave perpendicular to the direction of light propagation that queries the films for the presence of contaminants. Both sensors measure analytes that partition from the bulk solution into the polymer film. The GTRI sensor measures changes in the index of refraction of the polymer, and the ARCOVA sensor detects changes in the fluorescence of analyte-specific reporter dyes immobilized within the polymer matrix. The choice of polymers (GTRI) and polymer dye conjugates (ARCOVA) enables analytes to be differentiated, and the magnitude of the response is proportional to the concentration of the analyte. Standards are used to calibrate the response of

the photodetector, and an onboard microprocessor is used to convert changes in the index of refraction (GTRI) or fluorescence (ARCOVA) to analyte concentrations.

<http://www.serdp.org/Research/upload/ER-1605.pdf>

A Portable Fiberoptic Surface Enhanced Raman Sensor for Real-Time Detection and Monitoring of Perchlorate and Energetics (SERDP 2008 Grant)

SERDP Project ER-1602

Dr. Baohua Gu, PI, 865-574-7286, gub1@ornl.gov

Oak Ridge National Laboratory, Oak Ridge, TN

2008 Start: Anticipated Project Completion - 2011

Objective: Develop a new, cost-effective tool for in situ quantification and monitoring of perchlorate (and energetics such as RDX) in groundwater via fiberoptic surface-enhanced Raman scattering (SERS). (1) Fabricate SERS substrates using wet-chemical self-assembly and nanofabrication techniques; (2) construct a prototype fiberoptic SERS probe that is interfaced with a handheld Raman spectrometer; (3) develop and optimize methodologies by incorporating molecular recognition techniques with improved selectivity and sensitivity of SERS substrates; and (4) evaluate the performance and cost effectiveness of a new SERS probe for in situ field screening and monitoring at selected DoD sites.

<http://www.serdp.org/Research/upload/ER-1602.pdf>

Using Passive Polyethylene Samplers to Evaluate Chemical Activities Controlling Fluxes and Bioaccumulation of Organic Contaminants in Bed Sediments (SERDP 2006 Grant)

SERDP Project ER-1496

Dr. Philip Gschwend, PI, 617-253-1638, pmgschwe@mit.edu

MIT, Cambridge, MA

2006 Start: Anticipated Project Completion - 2009

Objective: Demonstrate the efficacy (accuracy of results, ease of use, low cost) of using polyethylene (PE) strips to assess the hazard posed by sediment beds contaminated by organic pollutants, such as PAHs and PCBs.

http://www.serdp.org/Research/upload/ER_FS_1496.pdf

U.S. DOE

A Cost-Effective Analytical Technology for Identification and Measurement of Greenhouse Gases (DOE 2008 SBIR Phase 2)

Lenterra Inc., West Orange, NJ

This project will develop a prototype of gas analyzer, based on a proprietary analytical technology that measures important greenhouse gas constituents. The project will result in the development of a cost-effective portable autonomous platform for environmental gas analysis.

Development of Aircraft Borne $^{13}\text{CH}_4$ Analyzer Using a Continuous Wave Quantum Cascade Infrared Laser Spectrometer (DOE 2008 SBIR Phase 2)

Mark S Zahniser, PI, mz@aerodyne.com

Aerodyne Research, Inc., Billerica, MA

Methane is the second most important greenhouse gas contributing to global warming. This project will produce a laser-based isotopic methane monitor that will be used to quantify the various sources of atmospheric methane based on their distinct isotopic signatures in order to assess the impact of methane on global warming and climate change.

In-Situ Monitoring of the Radioactive Contaminant ^{99}Tc in Ground Reagentless Equilibrium-Based Sensor (DOE 2008 STTR Phase 2)

Burge Environmental, Inc., Tempe, AZ

This project will develop a field-deployable monitoring system for the cost-effective and rapid determination of radioactive substances in the groundwater at federal sites, such as Hanford Site, Washington. The development of the system will decrease the future cost of site remediation.

Isotope Analyzer for Real-Time Measurements in the Field (DOE 2008 SBIR Phase 2)

Los Gatos Research, Mountain View, CA

The instrument developed will be the first gas analyzer capable of providing real-time measurements of methane isotopomers ($^{13}\text{CH}_4$, $^{12}\text{CH}_4$ and $\delta^{13}\text{C}$) in ambient air and thus enable fast, accurate quantification of methane oxidation in landfills, wetlands, and urban environments, as well as in oil and gas exploration and environmental research.

Low-Cost Small Diameter NMR Technologies for In-Situ Subsurface Characterization and Monitoring (DOE 2008 SBIR Phase 2)

Vista Clara Inc., Everett, WA

This project will develop low-cost, small-diameter NMR instrumentation and analysis software for subsurface characterization and monitoring. The technology developed through this program will be widely applicable to groundwater development, management, and remediation and monitoring of contaminated aquifers.

A New High-Resolution Method for the Characterization of Heterogeneous Subsurface Environments: Providing Flow and Transport Parameters via the Integration of MultiScale HYdroGeophysical Data (DOE 2008 SBIR Phase 2)

New England Research, Inc., White River Junction, VT

This project will develop a high-resolution geophysical method for environmental remediation that enables scientists to characterize, and integrate hydrogeologic properties at all scales. This represents a powerful new approach to understanding the flow and transport of contaminants in the heterogeneous subsurface.

In-Situ Monitoring of Uranyl Ion in Ground Water Using a Colorimetric-Based Sensor: Enabling the Mapping of Uranium Plume Migration of Contaminated DOE Sites (DOE 2008 STTR Phase 1)

Scott R. Burge, PI, burgenv@globalcrossing.net

Burge Environmental, Inc., Tempe, AZ, partnered with PNNL

Grant No. DE-FG02-08ER86341

Amount: \$99,830

This project will develop a field-deployable monitoring system for the cost-effective and rapid determination of radioactive substances in the groundwater at federal sites. An automated system using a preconcentrating column sensor will be used to monitor uranium concentrations. The system will be capable of being deployed and operated in the field for several months, measuring uranium concentrations below the regulatory limit of 30 ppb. The system will provide more frequent data with less reporting delay at a lower cost than the baseline methods. In Phase I, a prototype analytical system will be developed and tested.

Field-Deployable Water Isotope Analyzer for Stream Sampling (DOE 2008 SBIR Phase 1)

Manish Gupta, PI, m.gupta@lgrinc

Los Gatos Research, Mountain View, CA

Grant No. DE-FG 02-08ER84976

Amount: \$100,000

Remediation at DOE sites involves a variety of methodologies, including bioremediation, in which substances are injected into the subsurface to enhance microbial decomposition, and natural attenuation, in which natural, unaided processes are used to remediate waste. To better understand these remediation processes and maintain site stewardship, recent studies have explored the use of water isotopes ($2\text{H}/1\text{H}$ and $18\text{O}/16\text{O}$) to study flow paths. Currently, Isotope Ratio Mass Spectrometry (IRMS) is used to measure the stable isotope ratios of water; however, IRMS has several limitations including its need for a dedicated operator, its inability to measure multiple water isotopes simultaneously, and its operational expense. This project will develop a field-deployable analyzer based on cavity-enhanced laser absorption spectroscopy. The analyzer will be capable of continuously quantifying water isotope ratios from a water source without any significant conditioning and will provide isotope ratios to better than 1.0‰ in $2\text{H}/1\text{H}$ and 0.3‰ in $18\text{O}/16\text{O}$, which is sufficient for isotope hydrology studies.

Surface NMR Instrumentation and Analysis Methods for Characterizing Vadose Zone Hydrology (DOE 2008 SBIR Phase 1)

David Oliver Walsh, PI, davewalsh@vista-clara.com

Vista Clara Inc., Everett, WA

Grant No. DE-FG 02-08ER84979

Amount: \$100,000

This project will develop a new magnetic resonance imaging instrument plus analysis techniques to image and characterize groundwater and contaminant transport properties in the near subsurface. The instrument and analysis techniques will be widely applicable to 1) investigation and remediation of underground contamination and contaminated aquifers, 2) groundwater resource development, and 3) groundwater resource management.

In-Situ Isotope Hygrometer for Mapping and Monitoring Hydrogeologic Processes (DOE 2008 SBIR Phase 1)

Joerg Kutzner, PI, jkutzner@vistaphotonics.com

Vista Photonics, Inc., Santa Fe, NM

Grant No. DE-FG 02-08ER84980

Amount: \$100,000

This project will develop an isotope analyzer that can determine the isotope composition of liquid water samples. It will allow for tracing of the transport and dispersion of contaminants in the subsurface environment. The new instrument will cost-effectively measure $\delta^{18}\text{O}$, $\delta^{17}\text{O}$ and δD in water samples with a targeted precision below 1 per mil. The sensor will operate in real time and will need no sample preparation. In Phase I, telecommunication infrared laser diodes will be combined with photoacoustic spectroscopy to measure the isotope sample composition. A shoebox-sized device is targeted that will enable the eventual commercialization of rugged fieldable instrument at an estimated retail price of \$10K.

A Novel Method for Phytoextraction and Phytostabilization of Environmental Mercury (DOE 2008 SBIR Phase 1)

Mark Peter Elless, PI, ferguson@edenspace.com

Edenspace Systems Corporation, Chantilly, VA

Grant No. DE-FG 02-08ER85235

Amount: \$100,000

This project seeks to retire mercury from the environment by inducing the formation of insoluble mercury selenide (HgSe) in two recently identified Hg-accumulating plant species, one terrestrial and one aquatic. Phase I will attempt to demonstrate a high plant uptake of Hg and in plant conversion of environmental Hg to HgSe . Phase II will explore methods of increasing Hg uptake, confirm the low bioavailability under normal environmental conditions of the stabilized form, and conclude with a field demonstration. The technology should establish the foundation for a low-cost, solar-powered method of removing and stabilizing mercury over large areas of soil and large volumes of water.

A New Class of Nanocomposite Treatment Media for Efficient Mercury Remediation (DOE 2008 SBIR Phase 1)

Mohit Jain, PI, mjain@neicorporation.com

NEI Corporation, Somerset, NJ

Grant No. DE-FG 02-08ER85144

Amount: \$99,932

This project will develop a nanoparticle-based material that makes the reaction sites highly accessible to the mercury ions for efficient and fast removal. At the same time, the nanocomposite material will be amenable as a retrofit in existing treatment process equipment. Phase I will include a comparison between the proposed nanocomposite media and currently used sorbents and other treatment technologies.

Remote Characterization of Radiologically Contaminated Pipelines using Reactive Gaseous Tracers (DOE 2008 STTR Phase 1)

Wesley Lloyd Bratton, PI, bratton@vistaengr.com

Vista Engineering Technologies, LLC, Kennewick, WA partnered with Pacific Northwest Laboratories

Grant No. DE-FG02-08ER86366

Amount: \$99,670

This project will develop a remote characterization approach for evaluating pipelines at nuclear facilities to determine if residual radiological contamination exists within the pipeline. The measurements obtained have the potential to save hundreds of millions of dollars and significantly reduce the size and time of D&D and cleanup efforts throughout the nation.

High-Throughput Ultra-Fast Tunable Filter for Multispectral Imaging (DOE 2008 SBIR Phase 1)

Quincy Chen, PI, qchen@bostonati.com

Boston Applied Technologies, Inc., Woburn, MA

Grant No. DE-FG 02-08ER85110

Amount: \$99,957

This project will develop a unique filter technology based on an extremely large electro-optic effect of a solid inorganic material and a structured optical filter. It can change wavelengths in microseconds interval. This ultra-fast wavelength tuning ability enables higher spectral and spatial resolutions for remote sensing since more acquisitions can be taken in a given period of time.

A Field-Portable Polarization Imaging System for Remote Sensing (DOE 2008 SBIR Phase 1)

Hongzhi Zhao, PI, hzhao@bostonati.com

Boston Applied Technologies, Inc., Woburn, MA

Grant No. DE-FG 02-08ER85109

Amount: \$99,987

This project will develop a high-performing polarization imaging system, covering visible wavelengths to mid-infrared wavelengths. This system will find broad applications in both government and commercial markets and carry a tremendous commercial potential for the next generation of polarization imaging instruments.

Broadband Snapshot Complete Imaging Stokes Polarimeter (DOE 2008 STTR Phase 1)

Robert E. Sampson, Principal Investigator, resampsonita@aol.com

I Technology Applications, Ann Arbor, MI, partnered with the Univ. of Arizona, Tucson.

Grant No. DE-FG02-08ER86346

Amount: \$99,999

This project will develop a sensor to provide polarization information for remote sensing systems. The proposed sensor uses a Savart plate (SP) snapshot imaging polarimeter with an achromatic Fourier transforming (AFT) lens system. The AFT lens system is used as the polarimeter's rear optics in a unique configuration designed to provide polarization and spatial

information simultaneously. Phase I will concentrate on the design of the broadband polarimeter and components. In Phase II, a prototype instrument will be fabricated and tested. The sensor system is applicable to medical, geological, and environmental sensing problems.

Spectrally Agile Multispectral Imaging Sensor (DOE 2008 SBIR Phase 1)

Jame Yang, Principal Investigator, jyang@new-span.com

New Span Opto-Technology Inc., Miami, FL

Grant No. DE-FG 02-08ER85125

Amount: \$99,996

This project will develop a spectrally agile multispectral imaging sensor that will acquire and analyze object spectral signatures and be capable of very fast response time, high throughput, large aperture, and a wide spectral coverage. Phase I will conduct technical analysis and design, and construct a preliminary bench-top experimental setup to demonstrate critical technologies and the feasibility of the proposed concept. Commercial applications should arise in precision farming, the marine and coastal environment, natural hazard and pollution monitoring (oil spills, floods, volcanoes), oil and mineral exploration, and medical diagnostics.

Rapidly Tunable Optical Filter (DOE 2008 SBIR Phase 1)

Fred M. Levinton, Principal Investigator, flevinton@novaphotonics.com

Nova Photonics, Inc., Princeton, NJ

Grant No. DE-FG 02-08ER85126

Amount: \$99,970

This project will design and develop a rapidly-tunable, wide-field, birefringent, imaging optical filter with a large aperture. An electro-optic tuning element will allow for fast (~1 msec) switching times. The flexible design will permit bandwidths from ~100 nm to less than 1 nm. The filter has numerous applications for remote sensing, environmental monitoring, and medical imaging.

H-PDLC Tunable Filter for Hyperspectral Imaging (DOE 2008 STTR Phase 1)

Craig Richard Schwarze, Principal Investigator, cschwarze@optra.com

Optra, Inc., Topsfield, MA, partnered with Drexel University, Philadelphia, PA

Grant No. DE-FG02-08ER86355

Amount: \$99,744

This project will develop a tunable wavelength filter based on a holographically-formed, polymer-dispersed liquid crystal (H-PDLC). This device, a composite consisting of a polymer and micron sized LC droplets, will provide improved electro-optical properties compared to traditional LC materials. Advantages include faster switching times, wide wavelength operating range across the ultraviolet-to-infrared spectrum, narrow wavelength resolution, and high transmission. After feasibility is demonstrated in Phase I, Phase II will combine the H-PDLC filter with a compressive imaging architecture to realize a complete HSI system.

Remote Sensing through Imaging Polarimetry for Nuclear Non-Proliferation (DOE 2008 SBIR Phase 1)

Polaris Sensor Technologies, Inc., Huntsville, AL

This project will develop an infrared imaging system that forms images of infrared scenes using polarized light. Elements of the image that are not visible using unpolarized light are made visible and information about orientation of surfaces and objects can be obtained enhancing the detection of objects of interest.

Full Spectral Signature Simulation Models for Chemical Releases (DOE 2008 SBIR Phase 1)
Spectral Sciences, Inc., Burlington, MA

This project will develop chemical release signature models, a required technology for remote detection, identification, and monitoring of gases and activities associated with proliferation of weapons of mass destruction.

An In-Situ Instrument to Assess the Concentration and Phase Partitioning of Atmospheric Semi-Volatile Organic Compounds (DOE 2008 STTR Phase 1)

Susanne V. Hering, PI, Susanne@aerosol.us

Aerosol Dynamics, Inc., Berkeley, CA 94710-2401; 510-649-9360 partnered with University of California, Berkeley

Grant No. DE-FG02-08ER86335

Amount: \$100,000

Semi-volatile organic matter is pervasive in the atmosphere. Its effect on the earth's radiation balance depends on how this material is partitioned between the vapor and particle phases. No currently available instrumentation provides simultaneous, quantitative measurement of semi-volatile organic vapor and particle phases at the molecular level. Previous work involved the development of the Thermal Desorption Aerosol Gas Chromatography Mass Spectrometer (TAG), which provides identification and quantification of organic constituents in atmospheric particles at the molecular level with hourly measurements. In this project, the collection and desorption system of the TAG will be modified to provide quantitative data on the concentration and phase partitioning of semi-volatile organic species at the molecular level.

USGS Water Resources Research Institute

Development of a New Generation of Sensitive, Fluorescence-Based Nitrate Sensors for Use in Soil and Water (USGS 2008 WRRI Research Grant)

Project ID: 2007CT130B

Shawn Christopher Burdette, PI (University of Connecticut); Zoe G. Cardon, co-PI

Start Date: 9/01/2007

End Date: 8/31/2009

Federal Funds: \$ 22,885/Non-Federal Matching Funds: \$ 48,766

The aim is to start development of a new generation of nitrate sensor for use in soil solution or in fresh water. The sensor would be particularly helpful in monitoring efforts where persistent low levels of nitrate need to be measured. Although there are nitrate sensors currently

on the market, their sensitivity is geared toward hot spots such as plumes of contaminated water flowing from sewage treatment plants or from agricultural waste. A relatively inexpensive, miniaturized nitrate sensor is sorely needed by the monitoring, ecological, and environmental engineering communities, emphasizing sensitivity in the range of 0 to 3 mg/L. Fluorescent sensors are extremely useful chemical tools for measuring concentrations of metal ions, anions, and small molecules in a variety of environments because of their sensitivity, ease of use, small size and low cost. Most importantly, miniature, inexpensive fluorescent sensors can be deployed in arrays over wide areas and monitored easily for extended periods of time. Although sensors exist for a variety of analytes, there are very few viable fluorescent sensors for nitrate available, and none has been developed to the point of commercialization. Because of its unique chemical properties, binding and detecting nitrate represents a significant challenge. To address these issues, several strategies for engineering dendrimer-based sensors have been proposed. Dendrimers are particularly amenable to environmental sensing applications because of their robust structures (making them reusable) and ease of synthesis. All three strategies rely on binding and accumulation the negatively charge nitrate to generate a fluorescence response. In the first strategy, negative charge induces an isomerization of a fluorophore from a non-emissive to fluorescent form; the second, involves nitrate displacing quenching ions from dendrimer cores; and in the third, coupling dendrimer swelling to changes in fluorescence resonance energy transfer (FRET) between two fluorescent molecules. Each sensor system takes advantage of nitrate receptors designed to bind nitrate selectively in the presence of other anions present in nature. While the initial stage of the research project will address basic sensor design and detection strategy, the ultimate goal is integrate these molecular sensors into user-friendly devices that can be used by members of the ecological and environmental science communities.