Soil Gas Flux Measurements for Environmental Remediation and Reclamation

Chamber-based soil gas flux measurements are an important tool for understanding subsurface processes and ecosystem health. This article looks at a promising new method of evaluating petroleum spill sites by measuring the efflux of CO_2 produced by microbes during the biodegradation of hydrocarbons. We also consider the use of chamber-based soil CO_2 flux measurements for carbon cycle studies in restored mining lands.

"The CO_2 efflux methods are a significant improvement in source zone monitoring, and their technical defensibility, application ease, and cost-effectiveness will lead to replacing traditional methods and gain broad industry acceptance as best practice."
Tom Palaia, Principal Technologist at CH2M HILL.

Chamber-based soil gas flux systems measure gas exchange across the soil surface. The movement of gases across the soil-atmosphere interface provides an important insight into many below-ground processes. The efflux of CO_2 from soil to the atmosphere, for example, has been linked to microbial activities and the action of water on carbonates inside the soil profile.

Chamber-based soil CO_2 flux measurements are used in numerous applications including land reclamation, soil remediation, landfills, urban studies, wetlands, agriculture, and ecological research. This article considers chamber-based soil CO_2 flux measurement for land reclamation and remediation efforts following petroleum spills and surface mining.

Subsurface Remediation

It is not easy to assess subsurface contamination. Thanks to the microbial production of CO_2 during the biodegradation of petroleum hydrocarbons, soil CO_2 flux measurements can help delineate subsurface contaminant plumes and assess hydrocarbon biodegradation rates.

Researchers at the University of British Columbia are evaluating CO_2 efflux at the ground level as a proxy for the overall rate of subsurface biodegradation of petroleum hydrocarbons such as crude oil and ethanol-blended fuels. Biodegradation is an important component of natural source zone depletion or source zone natural attenuation, an alternative technology for cleaning up contaminated sites. A research study (Sihota et al., 2011) has shown the ability of the LI-8100A Automated Soil CO_2 Flux System to distinguish between the rates of natural CO_2 efflux and efflux resulting from contaminant biodegradation. The study site is within a shallow glacial outwash aquifer near Bemidji, Minnesota. A crude oil pipeline rupture contaminated the site in 1979. The LI-8100A system is being used in both survey and automated, multiplexed (4 chamber) configurations. "The instrumentation," says researcher Natasha Sihota, "is providing key information on the spatial distribution and temporal trends in gas emissions at our study sites."

Researchers note the versatility of the LI-8100A System. "In addition to evaluating gas emissions above crude oil spills," says Sihota, "we are using the LI-8100A System to monitor gas effluxes above ethanol-blended fuel spill sites. We are also developing laboratory experiments where we will use the LI-8100A System to monitor other gas emissions." Samples are extracted from the chamber head space and analysed in the laboratory for various gases. In addition, an optional GPS accessory is used for adding the location's coordinate information.

Scientists and engineers at CH2M HILL are using LI-COR's LI-8100A System to obtain natural source zone depletion rates at various petroleum remediation sites in western Canada. Field teams are periodically deployed to the sites to measure CO_2 efflux across the footprint of the release. The data are sent to analysts who perform a series of steps to reduce the data as needed to support site-specific remedial decision making. Efflux of hydrocarbon-derived CO_2 is calculated by subtracting background measurements from those collected over the spill areas. Biodegradation rates can then be estimated, says Principal

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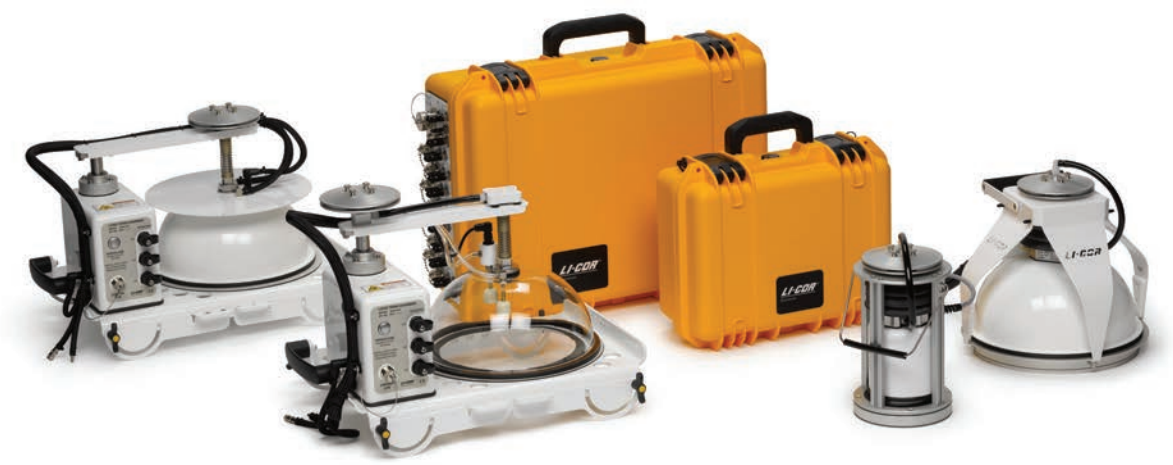


Technologist Tom Palaia, "by stoichiometrically equating the efflux of hydrocarbon-derived CO_2 with the mass of subsurface petroleum degraded using a representative hydrocarbon chemical formula." The results are used in planning and optimising remediation systems. "CO_2 efflux surveys in western Canada," says Palaia, "indicate that traditional practices for estimating the naturally-occurring petroleum hydrocarbon degradation rates largely underestimate it." Palaia sees CO_2 efflux measurement as the new way for monitoring subsurface contamination: "The CO_2 efflux methods are a significant improvement in source zone monitoring, and their technical defensibility, application ease, and cost-effectiveness will lead to replacing traditional methods and gain broad industry acceptance as best practice."

Land Reclamation Following Surface Mining

Soil CO_2 flux measurements can help evaluate land reclamation strategies following surface mining. Generally, the goal of land reclamation is a stable ecosystem with productivity equal to the original landscape. An important measure of a healthy ecosystem is net ecosystem productivity (NEP). NEP is a measurement of the net gain (or loss) of carbon in an ecosystem over a period of time. Some carbon is trapped in "pools" dead or living biomass and soil organic matter. Plants add to these pools through photosynthesis. Some carbon is lost through decomposition of organic matter in soil and leaf litter.

Researchers from Alberta Innovates – Technology Futures measured CO_2 flux to help quantify carbon dynamics and NEP in landscapes affected by oil sands mining. The study area is in the Athabasca Oil Sands Region of northern Alberta, Canada. Natural vegetation includes spruce, aspen, poplar, birch and pine trees and is typical of the Boreal forest region. Published results (B.L. Drozdowski, et al., 2010) show that carbon losses were nearly balanced by inputs in the early years following revegetation of mined lands, indicating a transition toward a healthy carbon-sink status. It was also determined that the peat mixes and other soil materials used for reclamation are breaking down and releasing nutrients in a way similar to natural soils. "Reclamation strategies that include the establishment and maintenance of a healthy vegetation cover," say the authors, "will result in the continued addition of carbon to the system."

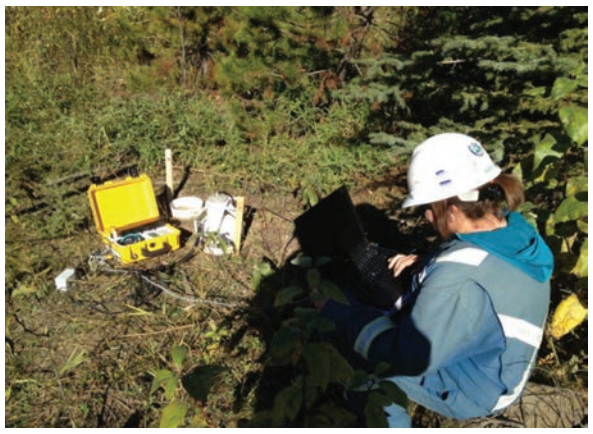
This study made use of the LI-8100 Automated Soil CO_2 Flux System for one-minute survey measurements every four hours between May and October at several sites in 2008 and 2009. In addition, long term soil CO_2 flux measurements were made using LI-8100 systems equipped with LI-8150 Multiplexer units. In addition to soil CO_2 flux measurements, techniques such as allometry, soil sampling, litter sampling, leaf area index, and canopy cover measurements were used to assess carbon pools in the ecosystem. Leaf area Index (LAI) is one-sided leaf surface area per ground surface area. Foliage is a carbon pool, but LAI is also positively correlated with photosynthetic potential in an ecosystem. LI-COR's LAI-2000 Plant Canopy Analyzer was used to measure LAI.

Chamber-Based Soil CO_2 Flux Measurement

Measuring soil CO_2 flux is not easy. Disturbance of the soil and local environment can affect gas production and transport. Covering the ground affects the diffusion gradient across the soil surface, and this in turn affects soil CO_2 flux rates. Variation in barometric pressure also affects the rate of soil CO_2 flux. Scientists at LI-COR Biosciences designed the LI-8100A Automated Soil CO_2 Flux System to address these challenges, making soil CO_2 flux measurements more accurate and easier to carry out.

The LI-8100A System measures soil CO_2 flux using enclosed chambers placed directly over the soil. Disturbances of environmental conditions are minimised by the use of soil collars placed well in advance of measurements. An automated option makes repeated measurements over days or months. Data processing adjusts for the altered CO_2 diffusion gradient caused by covering the soil, and a patented vent design equalises pressure inside the chamber with ambient pressure under both windy and calm conditions. The system also uses the proper level of mixing inside the chamber to avoid stagnant air pockets.

The LI-8100A System can track changes in soil CO_2 flux over time and space. The survey system is easily moved from collar to



collar, while the automated long-term multiplexing system can be deployed for months, with up to 16 chambers in an area of 30 meters in diameter. In addition to CO_2, other gases can be measured with the LI-8100A System by adding an auxiliary gas analyser or taking air samples from the chamber head space for analysis back at the laboratory.

Contact LI-COR to learn more about leaf area index, soil gas flux measurements, and other environmental monitoring applications.

References:

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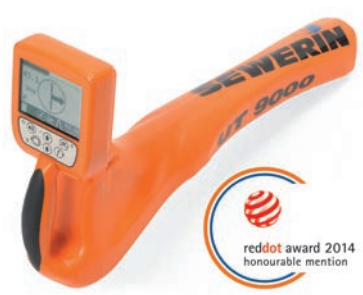

Cable Locator is Successful in the Red Dot Award 2014

With their new pipe and cable locator UT 9000, **Hermann Sewerin GmbH** from Guetersloh/Germany, succeeded in winning over the Red Dot jury. The 40 international design experts evaluated 4,815 entries from 53 countries in this year's Red Dot Award: Product Design. The UT 9000 by SEWERIN received an Honourable Mention, which honours particularly well-executed aspects of design work.

On 7 July 2014, the highlight of the internationally renowned product competition will be celebrated in Essen, Germany: the presentation of the acclaimed seal of quality during the traditional Red Dot Gala and subsequent Designers' Night. On that evening, roughly 1,200 guests from around the world gather in Essen in order to experience the awards ceremony. In the course of the party in the Red Dot Design Museum Essen, the winners' exhibition will also be opened, presenting the award-winning product UT 9000 to a wide audience for four weeks before it enters the museum's permanent exhibition.

The UT 9000 stands out with its innovative technology. Carefully balanced, lightweight yet sturdy: these are demands the UT 9000 fulfils with ease. It also impresses with a high-resolution display that is plainly legible even in strong sunshine, and cleverly structured, easily understandable menu navigation designed for intuitive usage.

Boasting over 70 frequencies, the UT 9000 is one of the most versatile pipe location devices on the market. Offering the unique option of scanning the ambient frequencies present before energizing a pipe, the UT 9000 helps users with selecting the right frequency. Undesirable interference fields are successfully suppressed, avoiding the detection of pipes which have been unintentionally energised at the same time.

Wireless communication between the receiver and generator allows the transmitting power and frequencies to be adapted for optimum detection. Equipped with one of the most powerful generators, the UT 9000 is ideal when locating very long pipe sections.

Operators of cable networks and their maintenance technicians will also quickly appreciate the benefits of the UT 9000. This device is not just designed for locating pipes but is also suitable when trying to locate cable faults.

For More Info, email: 29772pr@reply-direct.com

Monitoring Leaks from Biogas Storage Tanks

The GF320 Optical Gas Imaging (OGI) camera from **FLIR Systems** offers unmatched advantages for non-invasive monitoring of leaks from biogas storage tanks. Optical gas imaging using the FLIR GF320 offers tangible benefits compared to traditional biogas leak 'sniffers' because it can scan a broader area much more rapidly and monitor areas that are difficult to reach with contact measurement tools. The portable camera also greatly improves operator safety, by detecting emissions at a safe distance.

For More Info, email: 29942pr@reply-direct.com