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Using a Two-Dimensional Compound Specific Isotopic Analysis (CSIA) Approach to Differentiate Hydrocarbon Plumes

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At many sites, the groundwater concentrations of petroleum hydrocarbons are measured and compared against background concentrations and regulatory guidelines in order to determine plume delineation and regulatory exceedances. In some instances, the resulting petroleum hydrocarbon concentrations may be attributed to multiple source plumes that have been delineated as one larger contaminant plume. Differentiating contaminant plumes is beneficial for outlining remedial action plans (one source versus two sources), assigning liabilities for clean-up costs, and estimating plume stability (active versus historical sources and natural attenuation processes).

Various techniques are available to assist in the differentiation of these combined contaminant plumes. For example, petroleum hydrocarbon plumes are commonly differentiated by comparing the concentrations of hydrocarbon fractions F1 to F4 to determine the fuel type (e.g., gas versus diesel). However, additional lines of evidence may be required if the various plumes have originated from sources with similar fuel types (e.g., gasoline tanks) and/or weathering reactions have resulted in similar hydrocarbon fraction profiles for the different contaminant plumes. The collection of stable isotopes from co-mingled contaminant plumes can provide an additional line of evidence to "fingerprint" or distinguish between different petroleum hydrocarbon sources at a site. Stable isotopes ratios may be used to distinguish between different physical and biological processes that affect hydrocarbons in groundwater (assess natural attenuation) and/or discriminate between different sources (refined versus manufactured dissolved hydrocarbon products). This method is referred to as "Compound Specific Isotope Analysis (CSIA)" and it has emerged as an important tool in environmental forensics for source analysis at contaminated sites.

As part of the presentation, a case study involving the collection of stable isotopes (e.g., carbon and hydrogen) to differentiate a benzene contaminant plume will be discussed in order to highlight the benefits of the CSIA technique. In addition, the challenges in data interpretation and sample collection will also be discussed in relation to the requirements for the CSIA approach.

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Barbara is an Environmental Scientist and Project Manager with Dillon Consulting Limited in the Calgary office. She completed an undergraduate degree in Chemistry at the University of Calgary, graduate studies in geochemistry at the University of New Brunswick, and post-doctoral research at the National University of Ireland, Galway.

Her current project focus is mainly on environmental geochemistry of contaminated sites located in Alberta, British Columbia, and Atlantic Canada. She is involved with many aspects of contaminated sites including field sampling program design, data quality assurance/quality control assessments, water quality interpretation and the preparation of risk management plans. She is also involved with projects in the Northwest Territories including water licence applications, instructional course design, and site assessment work.

Her previous research experience was focused on nanoscale measurements of secondary mineral precipitates formed within mine tailings, the geochemical evolution of a river-recharged groundwater aquifer, salt-water intrusion within a coastal karst aquifer, and impacts of naturally weathered arsenic-bearing rocks on water quality.