# Two Wrongs Can Make a Right – A Novel Approach to the Biochemical Neutralization and Remediation of Cement-Impacted Soils

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An innovative applied research program was developed to investigate the viability of a novel biochemical remediation approach involving the treatment of cement-impacted soils by mixing them with sulphur-impacted soils. The study confirmed proof of concept for in situ neutralization and remediation of a cement-impacted site in southern Alberta and provided recommendations for potential field trial applications.

The cement-impacted site is located in an urban setting near a surface water body. The sulphur-impacted soil was obtained from a sour gas plant located in the Alberta foothills. A multidisciplinary approach, employing various lines of evidence, was used to evaluate whether combining these two impacted soils could turn “wastes” into “resources” for two contaminated sites. The investigation comprised:

- Design and execution of bench-scale microcosm experiments intended to simulate the in situ application of the proposed remediation technique under diverse conditions.
- Completion of comprehensive analyses on both soils types, including:
    - Petrological tests to determine mineral composition;
    - General soil chemistry analyses;
    - General porewater chemistry analyses; and
    - Acid-Base Accounting.
- Simulation of the in situ post-treatment soil conditions using hydrogeochemical modelling.
- Evaluation of potential groundwater impacts using transport modelling and output from the hydrogeochemical model.

The microcosm experiments successfully demonstrated that mixing cement- and sulphurimpacted soils effectively neutralized alkalinity within the batch samples. A reduction in pH to circum-neutral values was observed in all microcosms. The moisture content and routine mixing of the soil profile had very little impact on long term results. These results successfully demonstrated proof of concept for the proposed remediation technique. Additional key outcomes from this investigation included the following:

- It was confirmed that mixing of the two soils would not result in the cessation of microbially mediated sulphur oxidation.
- Kinetic rate constants for acid generation by sulphur-oxidizing bacteria were determined, allowing remediation time frames to be estimated using the geochemical model.
- Results from the acid-base accounting tests and modelling were used to identify mixing ratios that would not result in unacceptable groundwater quality impacts. Higher sulphur-impacted soil proportions would result in achieving remedial objectives more quickly but increase the risk of groundwater impacts. Optimal theoretical mixing ratios were determined on the basis of geochemical and transport modelling.

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## Kim McLeish

Dr. McLeish has 15+ years of experience as an environmental scientist in both a research and corporate capacity at Advisian. She has experience in landfill characterization (including leachate, landfill gas [LFG] and waste), landfill remediation, groundwater/surface water interaction, Phase 1 and 2 environmental site assessments, liability assessment, contaminant groundwater monitoring, soil vapour monitoring and residential water well assessments. She has worked for government agencies at the municipal, provincial and federal levels as well as various municipal and oil and gas clients. Currently, she is a project manager and provides technical support for several municipal environmental monitoring and remediation sites.

## Vincent Stein

Vincent Stein is a Principal Environmental Engineer with Advisian, a division of Worley. He holds a bachelor's degree in civil engineering and a master's degree in environmental engineering from the University of Calgary. He has over twenty years of environmental engineering experience, including two years as a research associate at the University of Calgary and eighteen as a consultant. His consulting experience has focused mainly on conducting and managing environmental site assessments and remediation programs at upstream oil and gas sites in Alberta. While at Advisian, he has continued his involvement with the University of Calgary by guest lecturing for undergraduate and graduate environmental engineering classes and participating in various research projects.

## Marc Bowles

Marc is the Technical Director for Wyndham Environmental Ltd. and has worked as an environmental consultant since 1992. He holds a bachelor's degree in geology and master of science degrees in applied mineral exploration and hydrogeology. His technical experience spans site characterization, contaminant hydrogeology, liability assessment/management, remediation, and litigation support as a qualified expert witness. Marc is the inventor of the Trench and Gate Remediation System, a proven methodology for in-situ treatment of groundwater contaminant plumes hosted in low permeability sediments.