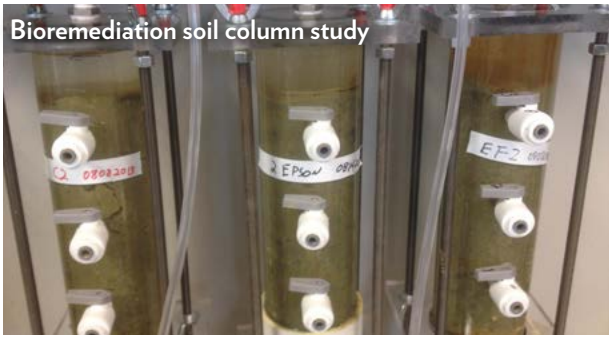
LANGAN

EXPERTS IN BENCH-SCALE TREATABILITY STUDIES

Langan staff work collaboratively with NJIT faculty and students

Batch treatability testing



Bioremediation soil column study

Bench-scale treatability studies are crucial for evaluating the alternative remedial technologies before any resources are invested in field activities, including additional pilot studies. Langan's environmental staff has direct "hands-on" experience performing treatability studies in order to evaluate a wide range of potential remedial technologies to support selection of the optimal remedy and meet the needs of each project.

Langan performs most laboratory-scale treatability studies "in-house" through a unique, collaborative partnership with the New Jersey Institute of Technology (NJIT) Center for Natural Resources Development and Protection. Langan's Treatability Facility at NJIT provides essential information for designing innovative, practical and cost-effective remediation systems, and supports the field remedial operation through in-house confirmation testing.

The Langan treatability facility is capable of evaluating the technology in the following setups:

- Microcosms
- Batch Reactors
- Columns
- Soil mixing

Langan Treatability Facility Tests:

- Aerobic Biodegradation
- Anaerobic Biodegradation
- Chemical Oxidation
- Reductive Technologies
- Solidification and Stabilization
- Air Sparging

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NJIT New Jersey's Science & Technology University

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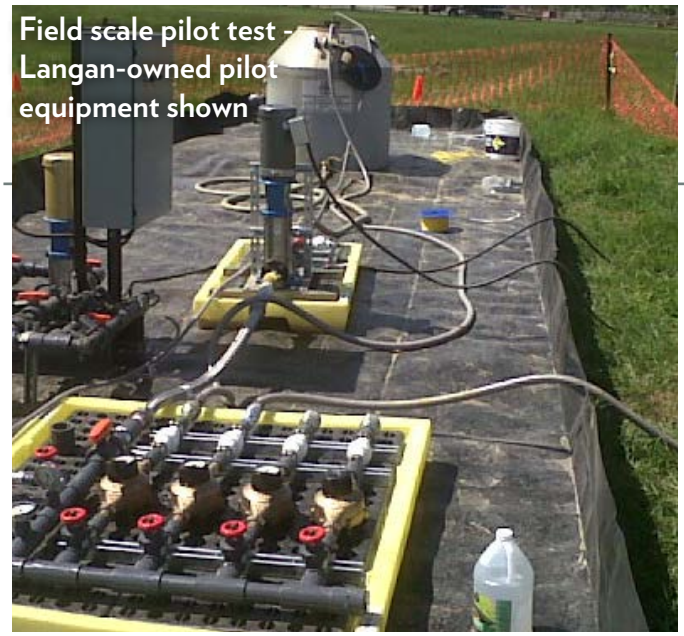
CHEMICAL OXIDATION (ISCO) TESTING



Field scale pilot test - Langan-owned pilot equipment shown

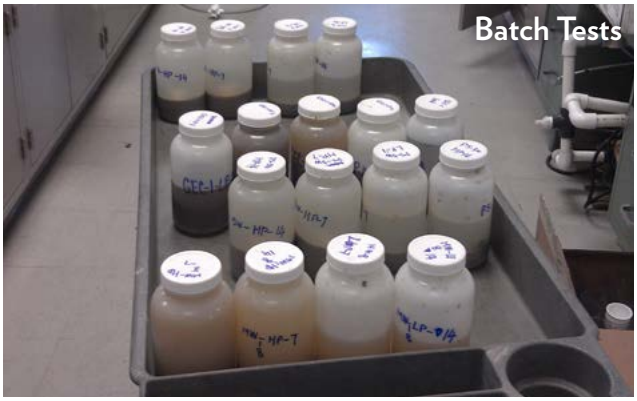
Langan conducts treatability testing services for ISCO technologies such as permanganate, hydrogen peroxide, persulfate, solid peroxides, and ozone.

The advantages of chemical oxidation include fast treatment (days, weeks), temporary field set-up, treatment to low levels, and effectiveness on many recalcitrant compounds. The disadvantages typically include fast consumption of the oxidants, significant initial spending commitments, rebound if contaminants are not destroyed, and special safety requirements. Most chemical oxidation applications are for high concentrations.

ISCO is impacted by various parameters including pH, temperature, concentration of reactants, metals (notably iron and manganese), competing organic compounds, and groundwater chemistry. Bulk parameters such as Soil Oxidant Demand (SOD) are used to assess oxidant dosage requirements. These SOD values are usually obtained through laboratory testing and can be useful as a screening-level treatability test by bracketing the range of oxidant dosages necessary. However, SOD tests do not provide information on the contaminant destruction efficiency kinetics. This type of information is provided via a formal treatability study, which is the next step after SOD testing.

Langan designs treatability tests based on the relevant site information. The results of the studies include method description, observations, data interpretation, conclusions, and recommendations such as:

- **what oxidant to use**
- **how much oxidant to use**
- **how effective in terms of contaminant destruction**
- **how fast the treatment is**
- **are there daughter products of concern**
- **is ISCO a viable option based on all of the above**



Batch Tests

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ZVI AND REDUCED METALS TESTING


Column Tests

Langan conducts proof of concept and designs optimization treatability testing services for microscale granular zero-valent iron (ZVI), nanoscale ZVI, and other reduced metals. We perform microcosm and column studies to determine loading rates and the effectiveness of specific treatments. Langan can also compare ZVI emulsion formulations, compare granular versus microscale or nanoscale iron treatments, assess biological versus abiotic processes, and evaluate bi-metallic particles treatments.

ZVI column studies can also be used to optimize design parameters for granular zero-valent iron permeable reactive barriers (PRBs), which are effective for treating chlorinated solvent groundwater plumes. ZVI column studies represent a critical step in the PRB design process. Continuous flow column studies at field scale groundwater seepage velocities simulate the typical 1-dimensional movement of groundwater through a PRB. Key PRB design parameters can be evaluated including:


ZVI Injection

- Product selection by comparing various ZVI materials or ZVI-sand mixtures, as well as simulated dispersed ZVI zone emplacements.
- Residence time (RT) of the contaminants of concern (COCs) required to achieve site-specific remedial objectives.
- PRB thickness design based on the RT required for treatment of the COCs and groundwater seepage velocity.
- Contaminant degradation half-life and assessment of breakdown products of degradation.
- Longevity of the treatment based on geochemical gradients in the columns, which can be used as

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