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SiREMNA™

SiREMNA™ - Inorganics Natural Attenuation Parameter Testing

For more information on how SiREMNA™ can help quantify important natural attenuation processes at your sites visit:

siremlab.com
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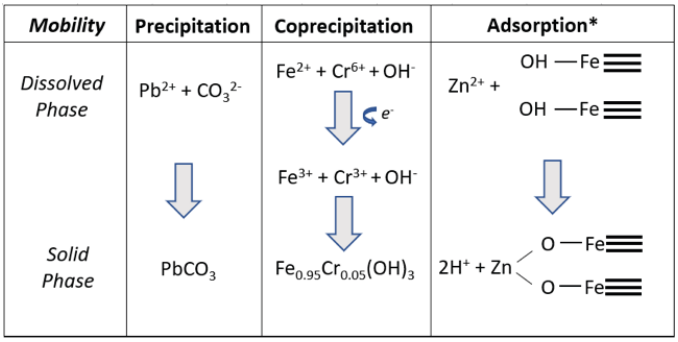
Monitored natural attenuation (MNA) is a cost-effective remedy for inorganic contaminants, which are produced by a range of industrial sectors and include metals, salts, sulfur compounds and nitrogen compounds. Traditionally, MNA focused testing for inorganics has not been widely available, and therefore SiREM has developed a comprehensive testing package (SiREMNA™-Inorganics) to evaluate the viability of MNA remedies for these contaminants.



*Adsorption onto iron oxyhydroxides is shown

FIGURE 1. Examples of contaminant-specific processes that may attenuate the transport of metals (Modified from 1).

Under certain conditions, natural processes may effectively reduce the mobility, toxicity, or bioavailability of inorganic constituents by precipitation as new minerals, coprecipitation, adsorption on the surfaces of soil particles or incorporation into the matrix of soil particles (Figure 1). Metals are not degradable but are subject to changes in solubility, bioavailability and sorption. In contrast to the degradation of organic compounds which results in their destruction, inorganic attenuation often involves immobilization via processes that may or may not be reversible. Therefore, regulatory guidelines for use of MNA for inorganic constituents stress the need for a detailed evaluation of mechanisms responsible for attenuation at a particular site, the attenuation rates, and the stability (i.e., reversibility) of these processes when background geochemical conditions return to the aquifer in the future following source control (1, 2).

SiREMNA™-Inorganics is a comprehensive analytical package to quantify NA processes for metals and other inorganic contaminants. The package is designed to provide data to assess the viability of MNA and for designing testing protocols in MNA remedies, including:

- The chemical and mineralogical characteristics of aquifer solids that provide attenuation capacity;
- The aqueous and solid phase chemical speciation of contaminants within the plume as well as unaffected upgradient and downgradient areas;
- Quantification of immobilization and/or sequestration processes that may control contaminant attenuation; and
- Collection of site-specific data to demonstrate the long-term stability of immobilized inorganic constituents.

Regulatory guidance emphasizes a tiered (phased) approach to inorganics MNA demonstration wherein the early tiers use existing information from groundwater samples to develop an initial conceptual site model (CSM) of NA processes. SiREMNA-Inorganics services apply to Tiers 2 and 3 where NA mechanisms, rates, capacities, and reversibility are evaluated based upon testing of aquifer solids samples. SiREMNA-Inorganics is a service package that provides the required non-routine Tier 2 and Tier 3 services.

The specific analyses offered under SiREMNA™-Inorganics are provided on the reverse.

References

[1] USEPA, 2007. Monitored Natural Attenuation of Inorganic Contaminants in Ground Water. Volume 1 - Technical Basis for Assessment. EPA/600/R-07/139

[2] USEPA, 2015. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites. Directive 9283.1-36

SiREMNA™ Methods for Evaluation of Natural Attenuation Processes for Inorganic Constituents

Medium	Type of Analyses	Relevance to Natural Attenuation	MNA Evaluation Tier*	Methodology
Groundwater	Total and dissolved elemental analysis	Targeted constituents, other cations, including iron and manganese	1	EPA Method 6020A (ICP MS)
	pH, ORP	Evaluation of background geochemical conditions	1	EPA Method 150.2, SM 2580B
	Major anions (chloride, sulfate, nitrate, phosphate)			EPA Method 300.1
	Carbonate Alkalinity			EPA Method 310.2
	Ferrous Iron	Dissolved iron speciation, confirmation of redox state, indication of process mediation by dissolution and precipitation of Fe species	1	HACH Method 8146
	Sulfate and Sulfide	Dissolved sulfur speciation, confirmation of redox state, potential for formation of iron sulfides	1	EPA Method 9056A, EPA Method 9030B
	Total Organic Carbon	Presence of energy source for microbially mediated elemental and mineral transformations	1	EPA Method 9060A
	Aqueous Metal Speciation	Aqueous species of redox-active metalloids (e.g., As[III,V], Cr[III,VI], U[IV,VI])	2	Various Methods (EPA Method 1632a, EPA Method 218, EPA 908)
Aquifer Solids	Cation Exchange Capacity (CEC)	Indicates relative adsorptive capacity for cationic metals	2	SW 9081
	Total Sulfur	Total amount of oxidized and reduced sulfur relevant to speciation of metals prone to coprecipitate with iron sulfides	2	EPA 6010B
	Total Sulfide		2	EPA Method 9030B, SM-4500S2-AD
	Organic Carbon Content	Presence of substrate for adsorption and energy source for microbially mediated mineral transformations	2	EPA Method 9060B (TOC)
	Total Elemental Analysis	Total amount of targeted constituents in the solid phase	2	EPA 7000B
	Sequential Extraction Procedure	Identification of the types of aquifer solids present and whether they are providing adsorptive capacity for various contaminants	2	Tessier et al (1979)
	X-Ray Diffraction, Scanning Electron Microscopy and energy dispersive x-ray analysis (EDXA)	Qualitative confirmation of mineral phases present and whether they contain targeted constituents	2	Customized evaluation
Laboratory tests with Site materials	Batch Adsorption Isotherm Tests	Evaluation of adsorptive capacity of the aquifer solids, development of site-specific partitioning coefficient that can be used in fate and transport modeling of plume attenuation	2	Customized evaluation
	Batch Desorption Tests	Evaluation of reversibility of adsorption reactions under changing future geochemical conditions after source control	3	Customized evaluation
	Column Breakthrough Tests	Evaluation under flowing conditions of attenuation capacity, rates, and stability of sequestered species.	2, 3	Customized evaluation

*Tiered MNA evaluation approach (Ref. 2): Tier 1. Demonstration of active contaminant removal from ground water & dissolved plume stability; Tier 2. Determination of the mechanism and rate of attenuation; Tier 3. Determination of the long-term capacity for attenuation and stability of immobilized contaminants; and Tier 4. Design of performance monitoring program.