

Arsenic Behavior under Sulfate-Reducing Conditions: Beware of the "Danger Zone"

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Keywords: arsenic, ORP, sulfide, sulfate-reducing, remediation

Throughout New England, naturally occurring arsenic is often present in groundwater at concentrations that exceed the new drinking water standard of 10 micrograms per liter. Although arsenic and other trace metals are ultimately derived from minerals in the underlying bedrock, these elements are subsequently redistributed through the glacial overburden by soil-forming processes. The geochemical mechanisms that control the partitioning of arsenic between soil and groundwater are complex and depend upon parameters that include pH and oxidation-reduction potential (ORP). Under oxidizing conditions, ferric iron oxide coatings on soil particles adsorb dissolved arsenic. Consequently, under high ORP conditions ($> +100$ mV), concentrations of arsenic in solution are usually low. When ORP is low (< -250 mV), sulfate in groundwater is reduced; iron, arsenic, and other trace metals may precipitate as sulfide minerals, and the associated aqueous concentrations again are low. In the “danger zone” between these extremes (ORP between ~ 0 and -200 mV), the iron oxides and sulfide phases dissolve; any arsenic associated with them is released, and groundwater concentrations under these conditions may be as high as several thousand micrograms per liter.

Remediation strategies for dissolved arsenic or organic contaminants (e.g., chlorinated solvents) often drive significant shifts in ORP. Therefore, arsenic may be either dissolved or precipitated in conjunction with certain treatment technologies. Remedial design, as well as regulatory oversight, must consider these geochemical processes in order to avoid undesirable consequences. If an active remedy drives ambient redox conditions toward the “critical” range (e.g., ~ -150 mV) from either direction, arsenic may be mobilized. Several examples from New England Superfund sites are shown, in which groundwater monitoring data validate this concern.