

# Chromium Remediation in Groundwater

## General Background

Chromium is present naturally in groundwater as the Cr(VI) anion and chromate ( $\text{CrO}_4^{2-}$ ) and various Cr(III) hydrolysis species ( $\text{Cr}(\text{OH})_2^+$ ,  $\text{Cr}(\text{OH})_3$ , and  $\text{Cr}(\text{OH})_4^-$ ). The predominant species present depends on the Eh and pH of the environment. The predominant species depends on the pH/Eh of the environment. Chromate predominates at higher Ehs (>500mV at pH6 and >300mV at pH9). At lower Eh values, the Cr(III) species are present at higher concentration than chromate with the specific dominant species dependent on pH. The dissolved chromium concentration in groundwater is strongly dependent on pH and Eh because Cr(VI) minerals are relatively soluble compared to Cr(III) minerals. Under oxidizing conditions where chromate is stable, total dissolved chromium concentrations can be much greater than 1 mg/L because of the high solubility of chromate minerals. Conversely, under more reducing conditions where Cr(III) species and minerals are stable, the total dissolved chromium concentration is typically much less than 1 mg/L because of the low solubility of Cr(III) minerals such as  $\text{Cr}(\text{OH})_3$  and  $(\text{Fe,Cr})(\text{OH})_3$ .

## Technical Approach

When chromium concentration in groundwater is above 1 mg/L, chromate is most commonly the cause. To remediate high concentrations of chromate in groundwater, a proven method is to reduce chromate to Cr(III), which in turn is removed from the groundwater by in situ precipitation due to the low solubility of Cr(III) minerals. With this strategy, questions often arise regarding the stability of the Cr(III) minerals in the environment and therefore the reversibility of the reaction after completion of active remediation. In many cases, the natural pH/Eh conditions of an aquifer favor the predominance of Cr(III) under equilibrium conditions, meaning the mineralization and removal of Cr(III) from the system is a stable, irreversible reaction.

In natural, unamended aquifer settings, reaching chromium redox equilibrium is a slow process. As such, Cr(VI) contamination may linger in an aquifer because its reduction to Cr(III) is slow, even though Cr(III) should be the dominant redox species of chromium. However, once chromate has been reduced to Cr(III), either by the introduction of a reductant or the (slow) effects of reductants naturally present in the aquifer, the precipitated Cr(III) minerals will not dissolve and recontaminate the aquifer.

## HRC Remediation

Hydrogen Release Compound (HRC) provides the reductant that drives the conversion of chrome (VI) to chrome (III), stimulating the rapid precipitation of the chrome complex in contaminated aquifers. Under the mediation of HRC and its by-products, the microbial population is able to remove oxygen, nitrate, sulfate, and other competing electron acceptors which in turn decreases the redox potential in the aquifer. Once redox potential is low enough, conversion to Cr(III) and subsequent precipitation may occur. The slow-release characteristics of HRC allow these reducing conditions to be maintained for a long period of time (up to 18 months) with a single application, making it a very cost-effective treatment option compared to alternatives.

When determining the best treatment options for chromium-contaminated aquifers, bear in mind that aquifer geochemistry plays a significant role in the success of any treatment. To ensure the success and longevity of treatment, it is encouraged that REGENESIS technical staff be supplied with site data including simple inorganic measures (common anions and cations) as well as basic physical parameters such as Eh, pH, temperature, and DO. With this data, REGENESIS will analyze the site-specific parameters and characteristics and, if all looks good, will aid in the design of an HRC remediation application and assist in the interpretation of field results at no charge.