CHEMICAL REDUCTION & GEOLOGICAL FIXATION BENCH SCALE STUDY

MANUFACTURING FACILITY
CONFIDENTIAL LOCATION

Client: **Private Consulting Firm**

Contaminants: **Hexavalent Chromium**

Impacted Matrix: **Saturated Soils and Ground Water**

Augmentations: **Metabisulfite, Thiosulfate, and Iron Compounds**

Project Overview: SE SCIENCES was contracted to access whether or not site conditions were favorable for the engineered reduction of the hexavalent chromate anion to a less toxic, less mobile precipitated trivalent form; combined with geological fixation to the subsurface soil matrix.

Technology Overview: Chemical reduction is the transfer of electrons between two or more ions resulting in a lower valent state in the reduced element.

hexavalent chromium (Cr^{+6}) $\xrightarrow{reduced}$ trivalent chromium (Cr^{+3})

Chemical reduction has been safely and effectively utilized as an in-situ remedial technology that can reduce hexavalent chromium (most commonly found as the chromate anion CrO_4^{-2} within ground water) into a less soluble, less mobile, and less toxic trivalent hydroxy species (e.g. $Cr(OH)_3$). In-situ treatments are typically facilitated with the delivery of a chemical reductant, working in combination with naturally occurring iron species and/or supplemented iron solutions. The injected solution establishes an in-situ reactive zone for redox sensitive compounds and constituents to be reduced.

Chemical equation for the thiosulfate based reduction of Fe^{+3}

$$S_2O_3^{-2} + 2Fe^{+3} + 2H_2O \longrightarrow 2SO_4^{-2} + 2Fe^{+2} + 4H^+$$

Chemical equation for the reaction of Fe^{+2} with chromate

$$3Fe^{+2} + CrO_4^{-2} + 5H^+ \longrightarrow Cr(OH)_3 + 3Fe^{+3} + H_2O$$

Pre-Augmentation – Reactors 1 & 2

Geological fixation relies on the capacity of the reduced chromium to affix itself onto subsurface soil solids rendering it immobile and stabilized. The fixation capacity of the subsurface soil matrix is dependant on many geochemical factors and conditions, which include: soil type, organic content, pH, ORP, temperature, and mineral concentrations.

Pre-Augmentation – Reactors 3 & 4

Project Evaluation Criteria: The slated goals of the battery of tests was to develop data that could be used in *(i)* identification and evaluation of chemical reagent(s) capable of reducing the hexavalent chromate anion to a stable trivalent hydroxy species; *(ii)* determination of relative efficacies of iron catalytic supplement(s); *(iii)* generating levels of chemical reduction efficacy under mimicked site specific conditions; *(iv)* identification and evaluation of naturally occurring geochemical interference factors; *(v)* quantification of the soils ability to fixate and stabilize the reduced chromium hydroxy species; *(vi)* evaluation of geophysical soil sample characteristics related to future field implementation.

Pre-Augmentation – Reactor 5, and Control Reactors 6 & 7.

Project Findings: Based on testing observations and analytical results, bench scale activities demonstrated the following:

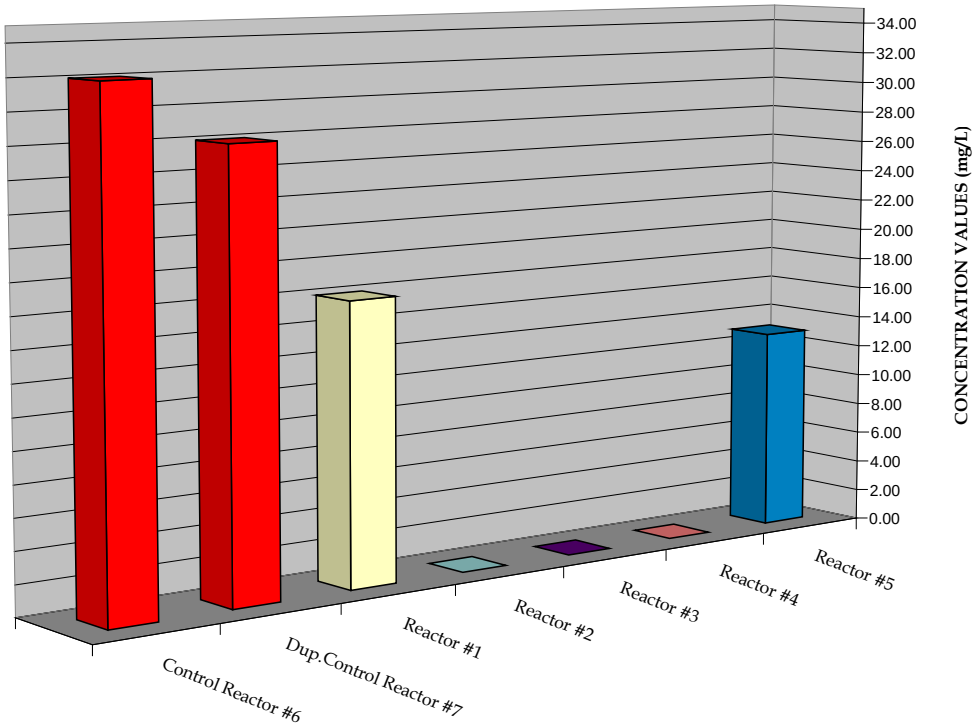
1. Complete hexavalent chromium transformation to the trivalent state within reactor batches #2, #3, and #4. The following table and chart illustrated the baseline hexavalent chromium concentrations of 32 mg/L (Control Reactor #6) and 28 mg/L (Duplicate Control Reactor #7), reduced to below laboratory detection limits within Reactors #2, #3, and #4 after augmentation.

HEXAVALENT CHROMIUM

Reactor ID	Value	Units	Reporting Limit	Augmentation
Control Reactor #6	32.00	mg/L	1.0000	None
Dup. Control Reactor #7	28.00	mg/L	1.0000	None
Reactor #1	18.00	mg/L	1.0000	B
Reactor #2	ND	mg/L	1.0000	A
Reactor #3	ND	mg/L	1.0000	B, C
Reactor #4	ND	mg/L	1.0000	A, D
Reactor #5	13.00	mg/L	1.0000	B, D

A: **Sodium Metabisulfite**
B: **Sodium Thiosulfate**
C: **Proprietary Iron Compound**
D: **Ferrous Sulfate**

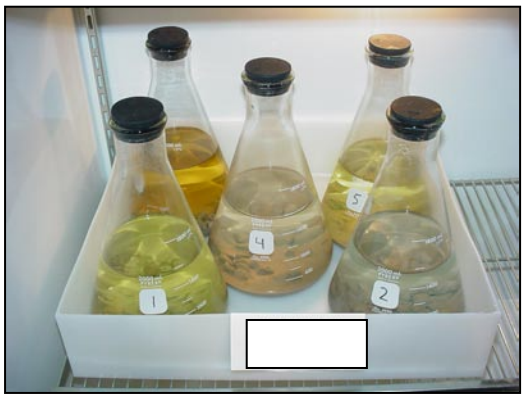
HEXAVALENT CHROMIUM CONCENTRATIONS



Project Conclusions: Data generated from bench scale study activities provided results which conclusively indicated hexavalent chromium reduction and geological fixation feasibility for the manufacturing facility site, via the addition of chemical reductant(s) and iron supplement(s).

Specifically, the sodium metabisulfite reagent demonstrated a greater overall efficacy and versatility as compared to the sodium thiosulfate reagent.

Both iron catalytic supplements (ferrous sulfate and proprietary iron compound) also provided favorable testing results.



Post-Augmentation – Reactors 1, 2, 3, 4, 5
21 Days

Post-Augmentation – Control Reactors 6 & 7
21 Days

Current Site Status:

Work Plan Development & Treatability Study Conceptual Design.