# Mixed Waste Remediation Using HUMASORB-CS™-an Adsorbent to Remove Organic and Inorganic Contaminants

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## Abstract

The groundwater contamination at different Department of Energy (DOE) and other similar industrial sites is complex due to the presence of both volatile organic compounds (VOC) and heavy metals. In a singlestep, the state-of-the-art technologies for treatment of contaminated water systems remediate only one class of contaminants, i.e. either VOCs or heavy metals. At sites having mixed contaminants, two different processes are required to remediate a site. The two-step approach increases complexity and the cost of remediation.

The objective of this project is to develop an adsorbent, HUMASORB-CS™, to remove heavy metal and organic contaminants from groundwater and surface water streams in a single processing step. The starting material for the development of HUMASORB-CS™ is a liquid humic acid product manufactured and marketed by ARCTECH, Inc. Humic acid is a complex aromatic macromolecule with various linkages between the aromatic groups. The different compounds involved in linkages include amino acids, amino sugars, peptides, aliphatic acids and other aliphatic compounds. The various functional groups in humic acid include carboxylic, phenolic, aliphatic and enolic-hydroxyl and carbonyl structures of various types. Metals are bound to the carbon skeleton of humic substances through heteroatoms such as nitrogen, oxygen or sulfur. The most common metal binding occurs via carboxylic and phenolic oxygen, but nitrogen and sulfur also have a positive effect on metal binding. The properties of HUMASORB-CS™ that are useful for mixed waste remediation include:

- high cation exchange capacity
- ability to chelate metals
- ability to adsorb organics

Humic acid was isolated, purified, cross-linked and immobilized by different methods to make HUMASORB-CS™. This material was then used for removing contaminants such as heavy metals, radionuclides, chlorinated and fuel hydrocarbons from simulated waste streams. At higher pH,

Research sponsored by the U.S. Department of Energy's Federal Energy Technology Center, under contract DE-AR21-95MC32114 with ARTECH, Inc. 14100 Park Meadow Drive, Chantilly, VA 20151

HUMASORB-CS™ developed in this project has a significantly lower solubility compared to purified humic acid. The effectiveness of HUMASORB-CS™ for contaminant removal has been evaluated in batch tests and in column studies with simulated waste streams. The accomplishments in the development of HUMASORB-CS™ include:

- evaluation of contaminant removal of capacity of purified humic acid
- cross linking/immobilization to form HUMASORB-CS™
- evaluation of solubility and contaminant removal characteristics of HUMASORB-CS™
- bench-scale column studies using HUMASORB-CS™
- stability of HUMASORB-CS™ in the presence of different ions
- conceptual design and economic analysis

Column tests were conducted with various simulated waste streams containing metals, radionuclide surrogates, oxo-anions and organics. Stability tests were conducted at elevated temperatures and also in the presence of ions such as carbonate and sulfate. HUMASORB-CS™ was tested in batch mode to evaluate its effectiveness for target contaminant after the stability treatment. The results from the tests show that HUMASORB-CS™ is stable and was effective for contaminant removal after the stability treatment. The future work during this project includes the following tasks:

- evaluate HUMASORB-CS™ under simulated barrier conditions
- enhance organic removal by incorporating zero-valent iron into HUMASORB-CS™ matrix
- validate process economics

The remediation of contaminated streams and groundwater has been traditionally approached with at least a two-step process including some combination of activated carbon and ion-exchange process. The removal of heavy metals from contaminated water has been accomplished by techniques such as the addition of a precipitating agent, ion-exchange or reverse osmosis. These techniques require considerable capital investment and in addition would require pretreatment in some cases to remove oil and suspended solids. HUMASORB-CS™, derived from a naturally occurring material has the potential to alleviate some of these limitations by combining remediation efforts into a single step process. HUMASORB-CS™ could be used for ground water cleanup, both in the *in-situ* mode and in a pump and treat process.

## Acknowledgments

We wish to acknowledge the support and guidance of Mr. Craig Hustwit and Dr. Venkat Venkataraman, the current and former Contracting Officer's Technical Representative (COTR) and DOE. The work on this project was performed between March 1995 and September 1997. The EM focus area for this project is decontamination and decommissioning.