Tailored Granular Activated Carbon (TGAC) for Well-Head Perchlorate Treatment

Christopher C. Lutes, ARCADIS, 4915 Prospectus Drive, Suite F (christopher.lutes@arcadis-us.com), Trent Henderson, P.E., BCEE, and David Liles, ARCADIS

Tim Pechman, Dr. James Graham, and Wes Hinson, Siemens Water Technologies; Dr. Fred Cannon, Judodine Patterson, and Robert Parette, Penn State University; and Dr. Mark Goltz, Daniel Craig, and Dr. Daniel Felker, Dr. Al Thal, Air Force Institute of Technology

Abstract
Several large perchlorate plumes have impacted at least 20 large municipal drinking water supply wells in California’s Inland Empire, resulting in their removal from service or installation of costly treatment systems. Although perchlorate removal technologies suitable for well-head application exist, there is a need to develop additional economical perchlorate removal technologies. In addition, conventional well-head technologies are specific for perchlorate only and are unable to effectively treat VOCs that are often co-contaminants.

In an ESTCP-funded technology validation project, ARCADIS, Siemens, PSU, and AFIT are demonstrating the application of TGAC for the removal of perchlorate from drinking water. The tailoring process attaches surfactants with quaternary ammonium groups to conventional GAC, which increases the perchlorate removal capacity by up to 35 times, while still allowing the GAC to remove VOCs. Cetylpyridinium chloride (CPC) was used as the surfactant in this project. Data to achieve regulatory and water purveyor acceptance are being generated in this pilot-scale test in Fontana, CA. We anticipate that the costs for TGAC treatment, including media, operations, and restoration, should be cost competitive in the presence of VOCs.

Objectives
1. Demonstrate a cost-effective treatment technology for removing perchlorate from drinking water to effluent concentrations of 1 µg/L or less.
2. Demonstrate that the technology allows low capital, operating, and energy costs.
3. Demonstrate that the technology requires simple operation and maintenance, and minimal monitoring.
4. Demonstrate that the technology can remove both perchlorate and Trichloroethene (TCE) simultaneously.

Technical Approach
• Perform TGAC Field Testing at the Fontana Water Company’s Perchlorate Treatment Facility
  • Three vessels in series (pictured at left) – 37 GPM
  • Six parallel small-scale systems, each operating at 1.5 gpm to study the system’s response to water quality variations (pictured at right)
• Perform Rapid Small Scale Column Tests (RSSCT tests) at Penn State University (PSU)
• Develop and Test Performance Predictive Software at the Air Force Institute of Technology (AFIT)

Conclusions
• TGAC technology has an excellent reliability profile over > 10 month operational interval of this demonstration.
• Manufacture of TGAC by two separate entities (Siemens and Penn State) resulted in products with reproducible perchlorate adsorption performance when comparing laboratory RSSCT data.
• TGAC showed approximately 2 times less perchlorate adsorption capacity before breakthrough than predicted by RSSCT at the Fontana, CA demonstration site. Possible causes are discussed on right side of poster.
• There is close agreement on the field-pilot system and RSSCT results for the mass of perchlorate adsorbed per unit of TGAC (see data on right side of poster).
• Lower pH values and increased chloride concentrations separately improve TGAC adsorption capacity based on RSSCT data.
• Higher nitrate concentrations (60 to 100 mg/L) and the presence of a low thiosulfate concentration (1 mg/L) reduce TGAC adsorption capacity based on RSSCT data.
• Laboratory-RSSCT data suggests the best TGAC performance is obtained at higher flow rates.
• Additional research as to suitability of individual tailoring agents for particular groundwater chemistry fingerprints may be desirable.
37 GPM Field-Scale System Results

6-Condition Small Scale Field System & RSSCT (Bench) Results

Observations:

- TGAC/GAC Virgin GAC: 643 mg per gram TGAC is less than predicted from bench-scale RSSCT tests.
- Competitively adsorbed perchlorate and other dissolved species may be responsible for lower breakthrough volumes in field tests.
- Field test can be reproduced by bench-scale test.
- Proportional diffusivity assumption may be applied to RSSCT tests for GAC, but not TGAC.

What May Be the Cause of the Observations?

- Competitive adsorption of perchlorate and other dissolved species.
- Difference in lab and field temperature.
- Inapplicability of the proportional diffusivity assumption to scale up RSSCTs for TGAC.

Effects of Competing Anions on Breakthrough Volume

• Tailoring surfactants at Penn State.

Effects of Increased Bicarbonate and Reduced pH

• Biodegradation of surfactants.

Effects of Competing Anions on Breakthrough Volume

• Ion exchange between lab and field.

Effects of Increased Bicarbonate and Reduced pH

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