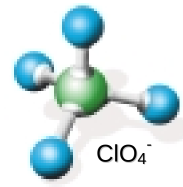
Perchlorate Treatment Technology
Fact Sheet

Ion Exchange



What is Ion Exchange?

Ion exchange is a technology used for the treatment of groundwater, surface water, and leachate. It works on perchlorate by capturing perchlorate anions on a positively charged resin and releasing a harmless chloride ion in its place. The exchange resin can be made from natural or synthetic organic, inorganic, or polymeric material that contain functional ionic groups. A typical ion exchange system consists of small resin beads that form a resin bed, which is usually two to six feet in diameter and one to six feet tall and contains millions of beads. The process generates a secondary waste stream in the form of a concentrated perchlorate brine and spent exchange resins, both of which require subsequent treatment and disposal. The ion exchange process consists of at least three distinct steps:

1. *Adsorption or loading* – Contaminated water is pumped through the system where exchange takes place. The rate of adsorption is dependent upon a number of factors such as resin selectivity, the concentration of the targeted contaminant ion in the water, the presence and concentration of competing ions, the flow rate, the size of the resin beads, and the diffusion characteristics of the ion within the porous structure of the beads.
2. *Regeneration* – A regenerant solution is used to displace the contaminant ions that are adsorbed on the exchange resin. Non-selective exchange resins require frequent regeneration for reuse, while selective resins typically require a more complex solution for regeneration.
3. *Rinse* – To extend the life of the exchange resin and to ensure proper flow characteristics before the next adsorption cycle, the resins are rinsed to remove the last traces of the regenerant solution from the resin.

Where Is Ion Exchange Being Used to Treat Perchlorate?

Private sector organizations have been successfully applying ion exchange for many years for different applications. This success has extended to continuous ion exchange units that have effectively demonstrated the ability to reduce perchlorate to below 4 ppb in remediation and drinking water applications. Ion exchange units are currently being used in California to generate drinking water from water containing perchlorate. The effectiveness of the system is evident in that the State of California has officially approved ion exchange for use in drinking water applications. A variation of the system that significantly reduces the amount of residual secondary waste generated by the process has also been developed.

The DOD has been investigating the use of ion exchange to treat perchlorate-contaminated ground-water at Edwards Air Force Base (AFB), California. Edwards AFB will soon begin field-testing a new class of anion exchange resins in a conventional fixed-bed ion exchange system. The resins were originally developed by scientists at the Department of Energy (DOE) Oak Ridge National Laboratory (ORNL) to treat groundwater contaminated by an anion that is chemically similar to perchlorate. Pilot-scale tests of the system finished in June 2001 and have proven successful at treating contaminated groundwater. A full-scale system is currently being designed and is expected to be operational in the Fall of 2002.

Site Facts

Location: Edwards AFB, California

Contaminated Media: Perchlorate-contaminated groundwater at concentrations ranging from 1,000 ppb to 160,000 ppb.

Treatment Technology: Ion exchange using selective, regenerable bifunctional ion exchange resin and tetra-chloroferrite displacement for regeneration of the resin. Testing will also be include an innovative brine destruction process.

Objective: Treat to below detectable levels.

Status: Full-scale execution planned for January 03.

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ClO_4^-

Edwards AFB Ion Exchange Description and Performance

Edwards AFB has four perchlorate-contaminated groundwater plumes with concentrations ranging from 160,000 ppb to less than 1,000 ppb. The source of the contamination is from solid-fuel rocket testing that occurred at the Jet Propulsion Laboratories in the 1950s and 1960s. Edwards AFB will be using a selective ion exchange technology developed at ORNL to treat groundwater containing perchlorate. Use of the technology appears to be a promising enhancement of the ion exchange process. Because of its selectivity for perchlorate, other chemical compounds typically found in groundwater do not readily impact the ion exchange resin, and laboratory studies have indicated it has the potential to significantly reduce the amount of secondary waste brine generated by the system. The system is in the final stages of the design phase, with full-scale implementation of the selective ion-exchange technology planned for the Fall of 2002. A low cost perchlorate-destruction process recently developed at ORNL is also being considered for use at Edwards AFB. It is anticipated that the use of the selective resin and the destruction process will dramatically reduce the volume of wastes produced during system operation, which will significantly decrease the overall cost of the process.

Cost Effectiveness

Capital and operational costs for ion exchange systems will vary depending on a number of factors, such as discharge requirements, the volume of water to be treated, contaminant concentration, the presence of other contaminants, resin and regenerant utilization, brine disposal, and site-specific hydrological and geochemical conditions. The costs of treating common water contaminants using conventional ion exchange systems range from \$0.30 - \$0.80/1,000 gallons treated. At this time, inadequate data is available to characterize the expected costs of using ion exchange systems to treat perchlorate-contaminated water at the scale expected to be encountered at DOD facilities. However, costs associated with the La Puente, California, system (an extremely large, continuous ion exchange system) included capital costs of nearly \$5 million (in 1999), operational costs of \$150.00/acre foot of water treated, and brine disposal costs of \$7.00/acre foot of water treated. However, actual costs are greatly dependent upon site-specific conditions.

La Puenta, California, Ion Exchange System

Advantages

- Proven ability to remove perchlorate to below 4 ppb
- Fast reaction and simple operation
- Can be operated at a high flow rate
- Regulator acceptance
- Cost effectiveness improving rapidly with technical innovation

Disadvantages

- High levels of suspended solids in wastewater may cause clogging of non-selective resins
- Waste brine from regeneration step requires treatment and disposal, though waste volume can be reduced with perchlorate removal and destruction
- Spent non-selective resins require frequent replacement and disposal
- Competitive uptake by other anions may limit the effectiveness of non-selective exchange resins
- Effectiveness of treatment is strongly influenced by water chemistry of a site (e.g., the presence of competing anions and the pH of the water source)