Perchlorate in Groundwater:

Established Treatment Processes / Remedial Action Alternatives

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Overview

Properties of Perchlorate

Established Treatment Processes
- ion exchange
- reverse osmosis
- biological treatment

Remedial Action Alternatives
- Ex-Situ Treatment
- In-Situ Treatment
  - (electron donor injection)
Perchlorate properties

- anion (-1)
- very high water solubility
- highly mobile, like nitrate
Established Treatment Processes

- Biological treatment
- Ion exchange
- Reverse osmosis / Nanofiltration
Remedial Action Alternatives

- Ex-Situ (pump & treat)
  - ion exchange
  - reverse osmosis
  - biological treatment

- In Situ Treatment Proposals
  - biological treatment
Treatment Processes
Ion Exchange

- Calgon ISEP+ System

- O&M costs estimated at about 2 times the cost of biological treatment
- Treatment/disposal of brine required
  - 250 deg C + catalyst (energy intensive)
Treatment Processes

Reverse Osmosis

- Removal efficiency > 80%
  - approx. 30 ppb to < 4 ppb

- O&M costs
  - treatment/ disposal of reject stream required
Treatment Processes
Biological

- Removal efficiency > 80%
  - approx. 150 ppb to < 4 ppb
- Scale 3200 gpm system @ Aerojet facility planning to expand to 8000 gpm
- O&M costs approx. $0.21 per 1000 gal*
  - complete destruction! (no reject or brine)
  - *includes ethanol, nutrients & utilities
Electron Donor Injection for In-Situ Bioremediation of TCE

- Has been used at several sites to treat chlorinated solvents and is also applicable to nitrates & perchlorate
- Defense Depot Hill Utah, Ogden Site
- Former Atlas Site 10 near York, NE
- Idaho National Engineering & Environmental Laboratory
Microbial Mechanics

- Gasoline + Air \rightarrow \text{drives engine}
- Gasoline (electron donor)
- Air (electron acceptor)
Electron Acceptors

- Oxygen
- Nitrate
- Iron III
- Sulfate
- Carbon Dioxide
Electron Acceptors

- Oxygen
- Nitrate / Perchlorate
- Iron III
- Sulfate / Chlorinated Solvents
- Carbon Dioxide
Electron Donors

- Ethanol (ex-situ, Aerojet bioreactor)
- Hydrogen Release Compound
- Sodium lactate solution
- Vegetable oil
Microbial Mechanics

<table>
<thead>
<tr>
<th>Electron Acceptor</th>
<th>Electron Donor</th>
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<tbody>
<tr>
<td>oxygen</td>
<td>lactate</td>
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<tr>
<td>nitrate + ethanol</td>
<td>perchlorate veg oil</td>
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</tbody>
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drives microbe
Electron Donor Injection

- Has been used at several sites to treat chlorinated solvents and at some sites to treat nitrates
- Principles are the same for perchlorate
- Perchlorate degrading microbes appear to be ubiquitous
- Risk of mobilizing some metals (e.g., arsenic)
Former Atlas 10 Site
HRC Field Demonstration

- TCE contaminated groundwater
- relatively high-permeability aquifer
- water table at about 60 feet bgs
- HRC injected from about 75 to 60 ft bgs
Defense Depot Hill Utah
Vegetable Oil Barrier

- TCE contaminated groundwater
- relatively high-permeability aquifer
- water table at about 20 feet bgs
- source removal (dig & haul)
- vegetable oil for treatment of source area residual
Conclusions

- Reverse osmosis, ion exchange & bio-reactors capable of approx. 80% (or greater) removal of perchlorate.
- For large scale ex-situ treatment, bio-reactors appear to be more cost-effective than ion exchange or reverse osmosis.
- In-situ bio-treatment appears to be a promising alternative if site geology permits.