Costs of Nitrate and Perchlorate Treatment

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Nitrate and Perchlorate

Why Nitrate and Perchlorate?
- Nitrate: A number of utilities exceed the nitrate MCL, particularly small systems
- Perchlorate: New state regulations and federal regulation consideration
- Both are fully oxidized – oxidation processes including aerobic biotreatment will not work
- The treatment processes that will work are pretty much the same
  - Anion exchange resin
  - High pressure membranes: reverse osmosis or nanofiltration
  - Anaerobic biological treatment (novel technology)
Publically Available Drinking-Water Treatability Database

- Interactive literature review database that contains over 88 regulated and unregulated contaminants and covers 34 treatment processes commonly employed or known to be effective (thousands of sources assembled on one site)

Currently available:
- Nitrate
- Perchlorate
- Microcystins
- PFOA, PFOS, PFTrA, PFDoA, PFUnA, PFDA, PFNA, PFHpA, PFHxA, PFPeA, PFBA, PFDS, PFHpS, PFHxS, PFBA, PFBS, PFOSA, FtS 8:2, FtS 6:2, N-EtFOSAA, N-MeFOSAA and GenX

https://www.epa.gov/water-research/drinking-water-treatability-database-tdb
Search: EPA TDB
Welcome to the Drinking Water Treatability Database

The Drinking Water Treatability Database (TDB) presents referenced information on the control of contaminants in drinking water. It allows drinking water utilities, first responders to spills or emergencies, treatment process designers, research organizations, academicians, regulators and others to access referenced information gathered from thousands of literature sources and assembled on one site. Over time, the TDB will expand to include over 200 regulated and unregulated contaminants and their contaminant properties. It includes more than 25 treatment processes used by drinking water utilities. The literature includes bench-, pilot-, and full-scale studies of surface waters, ground waters and laboratory waters. The literature includes peer-reviewed journals and conferences, other conferences and symposia, research reports, theses, and dissertations. By adding new contaminants and by upgrading references on existing contaminants, the TDB will always be a current source of information on drinking water contaminant control. Visit the About the TDB page for more information.

The TDB offers many features leading to the Data tab which is the heart of the TDB. After selecting a contaminant (Find a Contaminant), you will find a Treatment Processes tab that will present the list of treatment processes for which literature on the control of the contaminant was located. Selecting a treatment process, you will find a Data tab, like that shown below, that presents reference information, log or percent removal, water quality conditions and treatment process operational parameters. The Help page will aid you in navigating the TDB.
EPA’s Drinking Water Cost Models

- Adsorptive media
- **Anion exchange** *
- **Biological treatment** *
- Cation exchange
- GAC *
- Greensand filtration
- Microfiltration / ultrafiltration
- Multi-stage bubble aeration *

- Non-treatment
- Packed tower aeration
- **POU/POE**#
- Reverse Osmosis / Nanofiltration
- UV disinfection
- UV Advanced Oxidation


# For POU/POE search: EPA small system compliance help [http://water.epa.gov/type/drink/pws/smallsystems/compliancehelp.cfm](http://water.epa.gov/type/drink/pws/smallsystems/compliancehelp.cfm)
Primary Assumptions

- 20.3 mg N/L Influent
- Nitrate selective resin
- 420 Bed volumes before regeneration
- 2 minute EBCT
- Parallel contactors
- Brine discharge to POTW
Specific Design Modifications for Smaller Systems within the Cost Model

(Considers flows under 1 MGD)

- Construction issues (building)
- Residual handling flexibility
- Reduced spacing between vessels
- Smaller and no redundant vessels
- Reduced instrumentation
- No booster pumps
- No backwash pumps
- Reduced concrete pad thickness
- Reduced indirect costs
Primary Assumptions

- 20.3 mg N/L Influent
- Reverse osmosis treatment
- Replacement frequency:
  - RO membrane: 3 years
  - Pre filters: 9 months
  - Post filter: 12 months
- Groundwater
- No post UV disinfection
Primary Assumptions
• 20.3 mg N/L
• Fluidized bed reactor
• 28.5 mg/L acetic acid
• 2 mg P/L phosphoric acid
• 10 minute EBCT
• Post treatment aeration
• Post treatment filtration
• Recycle of spent backwash
Primary Assumptions:

- Influent 20.3 mg N/L
- Groundwater
- Low cost option
- IEX: Nitrate selective
- Biological: Fluidized bed
- POU: Reverse Osmosis
- 7% Discount rate

Cost: Nitrate (combined)
Includes both fluidized bed and fixed bed for anaerobic biological treatment

**Primary Assumptions:**
- Influent 20.3 mg N/L
- Groundwater
- Low cost option
- IEX: Nitrate selective
- Biological: Fluidized bed and Fixed bed
- POU: Reverse Osmosis
- 3% Discount rate
Perchlorate Regulatory Status

- EPA published a proposed perchlorate rule on June 26, 2019
- The public comment period closed August 26, 2019
- EPA is reviewing the public comments prior to final rule decision making, currently expected to be in December 2019

| Item | Proposed rule | Alternative 1 | Alternative 2 | Alternative 3
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MCLG</td>
<td>56 μg/L</td>
<td>18 μg/L</td>
<td>90 μg/L</td>
<td>None</td>
</tr>
<tr>
<td>MCL</td>
<td>56 μg/L</td>
<td>18 μg/L</td>
<td>90 μg/L</td>
<td>None</td>
</tr>
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</table>
EPA also proposed the following as BATs, which are affordable technologies for medium and large systems that are effective for perchlorate removal:

- Anion exchange
- Biological treatment
- Reverse Osmosis

EPA developed cost estimates for the regulatory benefit-cost analysis using work breakdown structure cost models, which estimate capital and operating costs given system size and treatment objectives.
Anion Exchange

- Ion exchange with chloride removes perchlorate from feed water
- Perchlorate-selective resin
- Lead-lag vessel configuration
- 1.5 minutes/vessel empty bed contact time
- Resin life 170,000 to 250,000 bed volumes
- Resin disposal (throw-away)
Biological Treatment

- Bacteria reduce perchlorate to chlorate, chlorite, chloride, and oxygen
- Fluidized bed/ Fixed bed configuration with 10-12 minutes contact time
- Electron donor (substrate)
- Raw water quality (e.g., temperature and nutrients)
- Nutrients addition
- Post-treatment (aeration, GAC polishing, and disinfection)
- Excess biomass removal and disposal
Reverse Osmosis

- Steric exclusion (also electrostatic repulsion for UF membranes)
- Feed water pretreatment (filtration, acid addition and anti-scalant)
- Post-treatment pH adjustment (corrosion control)
- Recovery rate
- Concentrate disposal
For small systems, EPA identified several compliance technologies as affordable using the following approach:

• Estimated annualized costs for three size categories (using EPA’s work breakdown structure models, which estimate the capital and operating costs for model systems)

• Compared annualized costs to an expenditure margin equal to 2.5% of median household income minus average annual baseline household water utility costs

• Identified SSCTs where annualized costs < expenditure margin
Perchlorate Technologies and Cost Document

Includes both fluidized bed and fixed bed for anaerobic biological treatment

Primary Assumptions:
- Influent: 24 – 270 ug/L
- Groundwater
- Low cost option
- IEX: Perchlorate selective
- Biological: Fluidized & fixed bed
- POU: Reverse Osmosis
- 7% Discount rate
Cost: Nitrate (combined)

Includes both fluidized bed and fixed bed for anaerobic biological treatment

Conditions Same as Previous Slides:
- Influent 24 ug/L
- Groundwater
- IEX: Perchlorate selective
- Biological: Fluidized & fixed bed
- POU: Reverse Osmosis
Rule Costs

• For both entry points exceeding 56 μg/L (and those exceeding 18 and 90 μg/L), EPA assumed the affected systems would use anion exchange because it’s most cost-effective for the impacted system sizes:
  • Perchlorate-selective resin
  • 2 vessels in series (lead-lag)
  • 1.5 minutes contact time (3 minutes total)
  • 170,000 bed volumes
  • Throw-away resin
Summary of results show that SSCTs vary by system size

<table>
<thead>
<tr>
<th>System Size (Population Served)</th>
<th>Ion Exchange</th>
<th>Biological Treatment</th>
<th>Reverse Osmosis</th>
<th>Point-of-Use Reverse Osmosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-500</td>
<td>$378 to $610</td>
<td>$2,146 to $3,709</td>
<td>$2,272 to $2,671</td>
<td>$265 to $271</td>
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<tr>
<td>501-3,300</td>
<td>$98 to $148</td>
<td>$324 to $566</td>
<td>$561 to $688</td>
<td>$250 to $251</td>
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<tr>
<td>3,301-10,000</td>
<td>$104 to $153</td>
<td>$211 to $315</td>
<td>$431 to $493</td>
<td>Not applicable</td>
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Occurrence and Exposure Estimates for the Proposed and Alternative MCLs Based on UCMR1 (max value exceedances)

<table>
<thead>
<tr>
<th>Affected Entity</th>
<th>Small Systems</th>
<th>Large Systems</th>
<th>Total Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCLG = MCL 56 (\mu g/L)</strong></td>
<td></td>
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</tr>
<tr>
<td>Entry points (population)</td>
<td>0 (0)</td>
<td>2 (32,432)</td>
<td>2 (32,432)</td>
</tr>
<tr>
<td>Water systems (population)</td>
<td>0 (0)</td>
<td>2 (64,733)</td>
<td>2 (64,733)</td>
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<tr>
<td><strong>Alternative MCLG = MCL 18 (\mu g/L)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Entry points (population)</td>
<td>1 (2,155)</td>
<td>16 (618,406)</td>
<td>17 (620,561)</td>
</tr>
<tr>
<td>Water systems (population)</td>
<td>1 (4,309)</td>
<td>14 (696,871)</td>
<td>15 (701,180)</td>
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<tr>
<td><strong>Alternative MCLG = MCL 90 (\mu g/L)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Entry points (population)</td>
<td>0 (0)</td>
<td>1 (25,972)</td>
<td>1 (25,972)</td>
</tr>
<tr>
<td>Water systems (population)</td>
<td>0 (0)</td>
<td>1 (25,972)</td>
<td>1 (25,972)</td>
</tr>
</tbody>
</table>
Conclusions

For drinking water applications...

• Selective anion exchange resins are the lowest cost technology for a wide range of systems sizes for both nitrate and perchlorate.

• For extremely small systems (100-200 homes), point-of-use technologies (reverse osmosis) can be the lowest cost technology for both nitrate and perchlorate.

• For larger systems, biological treatment systems are the lowest cost, although the low perchlorate concentrations and the high capacity of perchlorate-selective resins makes this difficult, unless the influent perchlorate concentrations are higher, such as that seen in remediation sites.
Questions?
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