Fixed-Bed Biological Process Eliminates the Need for Concentrate Handling

Nitrate is the most common groundwater contaminant in the United States. Due to its ability to cause methglobenemia (blue-baby syndrome, which causes loss of oxygen carrying capacity of the blood), nitrate has a primary drinking water standard of 10 mg/L NO₃-N.

Perchlorate, a groundwater contaminant that disrupts the generation of metabolic hormones, has been found in the drinking water supplies of millions of people. Though no federal standard exists for perchlorate, the California Department of Public Health (CDPH) has established a 6 µg/L limit.

Water treatment plants affected by nitrate and/or perchlorate typically utilize ion exchange (IX) or reverse osmosis (RO) membranes to target the removal of these contaminants. While IX and RO are effective at separating nitrate and perchlorate from the process stream, they both produce a high-strength, nitrate/perchlorate-laden waste stream that must be further treated or disposed, typically at a substantial cost.

Carollo Engineers has developed a new fixed-bed (FXB) biological nitrate/perchlorate removal process as an alternative to IX and RO processes to avoid the generation of costly and unmanageable concentrate streams. The FXB biological process utilizes a stationary bed of granular activated carbon (GAC) on which biofilms containing nitrate/perchlorate-reducing bacteria develop. Water is drawn from a well, amended with an electron donor such as acetic acid, and then pumped across the GAC bed. Bacteria in the bed convert nitrate to N₂ gas and perchlorate to chloride. A one-time acclimation period is required to develop the appropriate biological activity, which is done by contacting virgin GAC with raw water and acetic acid for two to three weeks (i.e., bacteria indigenous to the local raw water supply provide the requisite biological activity). Carollo has received conditional approval from the CDPH for the use of FXB bioreactors to remove nitrate and perchlorate from drinking water.

The FXB biological process has key features that make it an attractive nitrate/perchlorate removal technology. These features include:

- **Robust**: Hydraulic and water treatment performance is essentially independent of raw water quality and treatment goals and is insensitive to wide swings in operating conditions.
- **Green**: Low-energy process that eliminates nitrate from the environment rather than concentrating it, avoids the addition of salt to a given watershed and the generation of a high-strength brine stream, and can achieve high water recoveries greater than 96 percent.

Biofilms that form on the surface of GAC are robust.

Instead of concentrating contaminants, the fixed-bed biological process converts contaminants to innocuous end products.

Electron Acceptor

- \( \text{O}_2 \)
- \( \text{NO}_2^- \)
- \( \text{ClO}_2^- \)
- \( \text{BrO}_3^- \)

Electron Donor

- \( \text{CH}_3\text{COOH} \)
- DOC
- Trace Organics

\[ \text{H}_2\text{O} \quad \text{N}_2 \quad \text{Cl}^- \quad \text{Br}^- \]

\[ \text{CO}_2 \]
Cost-effective: Low-energy demand, the lack of salt regeneration, and the avoidance of a high-strength, nitrate-laden concentrate waste stream all contribute to low O&M/life-cycle costs relative to IX and RO.

Flexible: Can remove multiple contaminants in a single reactor and across the two-stage process. Nitrate, perchlorate, chromium (VI), selenium, some volatile organic compounds (VOCs), uranium, and arsenic can all be addressed without multiple add-on unit processes.

Straightforward: Comparable in design and operation to conventional granular media filtration. It is also highly automated, so little operator attention is required.

Pilot testing at the Western Municipal Water District’s Arlington Desalter facility (Riverside, California) has confirmed the aforementioned benefits of FXB biological nitrate treatment. All conditions of the CDPH technology approval letter have been met, and the preliminary design is complete. The most important aspect of this technology is that nitrate/perchlorate destruction eliminates the need for concentrate handling, making the process sustainable. As costs for concentrate handling continue to escalate, the FXB biological process will likely become an increasingly important option for utilities dealing with nitrate and/or perchlorate contamination.