Two-stage, Fixed-bed Biodenitrification at the City of Delano: Pilot Testing to Full-scale Implementation

Jess Brown, Penny Carlo, Chris Cleveland, Giridhar Upadhayaya, Jeff Riley, Pei-Shin Wu
This presentation will cover...

1. Background
2. Delano Piloting Results
3. Full-Scale Construction and Operation
Background
Nitrate Is One of the Most Common Groundwater Contaminants in the US
Universe of Treatment Alternatives

Nitrate, VOCs, Cr(VI)

Membranes
- Pressure
  - NF/RO
- Electrical
  - EDR
- Conventional
  - Single Use Resins

Ion Exchange

GAC
- Liquid Phase
- Gas Phase (w/ Air Stripping)

Other
- Filtration
- Oxidation
- Multiple

EDR
- UV/AOP
Existing Technologies Present Some Challenges

- Generate high-strength, contaminant-laden waste
- Often target a single contaminant
  stacked treatment processes required for multi-
  contaminant applications → increased costs & footprint
- O&M costs can be substantial
  high headloss across multiple unit processes; waste
  handling/disposal; high media regeneration or change-
  out frequency, etc.
- Treatment efficiency often impacted by raw water quality
Two-Stage, Fixed-Bed Biotreatment Realizes Multiple Benefits

- Multiple contaminants
- Contaminant destruction
- High water recovery
- Low energy/ops costs
- Natural & Sustainable Process
- Robust
Bacteria Oxidize and Reduce Contaminants to Generate Energy and Grow

- Nutrients: (P, NH₃)
- Organic carbon
- VOCs

O₂, NO₃⁻, ClO₄⁻, Cr(VI)

EPS

CO₂, N₂, Cl⁻, Cr(III)₅
Fixed-Bed Biological Treatment is Based On Conventional Granular Media Filtration

Granular Media Filter + Chlorine = Fixed-Bed Bioreactor
Biologically-Tailored, Two-Stage Treatment Approach:
Meets water quality objectives and is designed for automated operation and robust performance

Well(s) -> Nutrients -> Anoxic Bioreactor

Anoxic Bioreactor -> H₂O₂, Polymer, Degas (if necessary) -> Aerobic Biofilter

Aerobic Biofilter -> Disinfection

Backwash wastewater to settling lagoon or sewer
Fixed-Bed Biological Treatment Received DDW Conditional Approval in 2004

November 15, 2004

Jess C. Brown, Ph.D.
Project Manager, Biological Treatment
Carollo Engineers
10540 Talbert Avenue, Suite 200 East
Fountain Valley, California 92708

Dear Dr. Brown:

CONDITIONAL ACCEPTANCE OF FIXED-BED BIOLOGICAL TREATMENT FOR THE PRODUCTION OF DRINKING WATER FROM PERCHLORATE CONTAMINATED WATER

ANNEX (ATC) of the Drinking Water Program in the California Department of Water Resources submitted the following document submitted with the request for fixed-bed biological treatment as a means of reducing perchlorate in drinking water supplies.
Delano Well 35 Project Objectives

1. Demonstrate treatment effectiveness for removing nitrate from Well 35 groundwater
2. Demonstrate system robustness
3. Assess full-scale operation requirements
4. Support water supply permit application to operate full-scale facility in rural settings
5. Familiarize City staff with the system
Delano Piloting Results
Well 35 Pilot Study – Testing Phases

1. Acclimation & Optimization (Phase 1)
2. Steady-State Operations (Phase 2)
   a. Disinfection (CT) Testing
   b. DBP Formation Potential (DBPFP) Testing
3. Challenge Testing (Phase 3)
   a. Raw water quality fluctuation
   b. Acetic acid feed failure
   c. System shut-downs
4. Intermittent Operation Testing (Phase 4)
Pilot Matches Full-Scale Process Flow

Sampling Locations
1. Raw (1F)
2. Bioreactor Effluent (1E)
3. Biofilter Effluent (2E)
Pilot Matches Full-Scale Process Flow
Rapid Acclimation with Fresh GAC Media
Sustained Nitrate Removal Observed
Turbidity Goals Met

99.5% of samples below 0.3 NTU
Robustness Testing
System Performance Not Impacted by Increase in Raw Water Nitrate
Rapid Recovery following Acetic Acid Feed Failure
System Is Robust with respect to 24-Hour System Shut-Down

![Graph showing nitrate and nitrite levels over time. The graph includes a treatment goal and data points for raw nitrate + nitrite and effluent nitrate + nitrite. The goal is met after a significant period.]}
System is robust with respect to 1-month system shut-down.
Phase 4 Testing - Intermittent Operating Scenarios

1. 24/7 Operation (Baseline Condition)
2. **On** 20 hours/**off** 4 hours
3. **On** 12 hours/**off** 12 hours
4. **On** 6 hours/**off** 18 hours
5. **On** 1 week/**off** 1 week
6. **On** 100 hours/**off** 68 hours
7. **On** 45 minutes/**off** 15 minutes, repeated for 12 hours, then **off** 12 hours
8. **On** 33 minutes/**off** 33 minutes, repeated for 12 hours, then **off** 12 hours.
Steady Performance: 12 hrs on/12 hrs off
Steady Performance: 1 week on/1 week off
Steady Performance: 33 min **on**/33 min **off** for 12 hours, then **off** for 12 hours
Pilot Testing Summary

• Efficient nitrate removal observed and water quality objectives met
• System effluent is readily disinfected
• System effluent has a low DBP formation potential
• Backwash wastewater is low strength
• System is robust
  – Backwashing
  – Raw water nitrate fluctuation
  – Acetic acid feed failure
  – System shut-downs
  – Intermittent operation
Full-Scale System
### Demonstration Facility: Design Criteria

<table>
<thead>
<tr>
<th>Description</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well 35 Flow Rate</td>
<td>570 gpm</td>
</tr>
<tr>
<td>biottta™ Average Flow Rate</td>
<td>200 gpm</td>
</tr>
<tr>
<td>biottta™ Maximum Flow Rate</td>
<td>350 gpm</td>
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<tr>
<td>Raw Water Nitrate Concentration</td>
<td>45 mg/L as NO₃</td>
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<tr>
<td>biottta™ Target Nitrate Concentration</td>
<td>5 mg/L as NO₃</td>
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<tr>
<td>Blended Water Target Nitrate Concentration</td>
<td>31 mg/L as NO₃</td>
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<tr>
<td>Number of Vessels</td>
<td>2</td>
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<tr>
<td>Vessel Diameter</td>
<td>8 feet</td>
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<tr>
<td>Bioreactor Media Type and Depth</td>
<td>48 inches GAC</td>
</tr>
<tr>
<td>Empty Bed Contact Time (EBCT) at Average Flow</td>
<td>7.6 minutes</td>
</tr>
<tr>
<td>Biofilter Media Type and Depth</td>
<td>36 inches GAC over 12 inches sand</td>
</tr>
</tbody>
</table>
Well 35: Existing Site

Existing Well 35

Valle Vista Park

Austin Street

biottta Pilot Structure
Demonstration Facility Layout

- Expand Site to the East
- Chemical Storage
- Existing Well 35
- biottta™ Treatment Building
- Backwash Supply and Waste Equalization Tanks
Demonstration Facility Layout
Demonstration Facility Layout
Full-scale System Construction
Full-scale System Construction
Full-scale System Construction
Full-scale System Construction
Full-scale System
Complete Nitrate Removal Observed with Full-Scale System
System Performance Summary

- Efficient removal of multiple contaminants can be achieved while avoiding add-on unit processes.
- System is robust.
- Design is modular and flexible.
- Low energy
- Does not generate a contaminant-laden, concentrated waste stream
Acknowledgments

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- California Division of Drinking Water
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- Technical Advisory Committee
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- AdEdge Water Technologies
- PCL Construction
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