A New Approach to Drinking Water Nitrate Removal

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Director of Business Development
Presentation Outline

1. Nitrate Market & Treatment
2. Microvi Solution & Sunny Slope Project
3. Questions
Nitrate Market & Treatment
United States - Nitrate Contamination Arizona

Figure 3: This figure shows predicted concentrations of nitrate-N in groundwater. Over 9% of the state, or 12,200 square miles, has an 80% chance (probability) of nitrate groundwater contamination exceeding 5 mg/L, half the drinking water MCL.
Available Treatment Technologies

- **Nitrate Removal**
  - Ion Exchange
    - Conventional, Specialized Resin, Counter Current, Multiple Vessel Configuration, WBA IX
  - Reverse Osmosis
    - Process & Membrane Improvement and Modification
  - Electrodialysis
    - EDR
    - SED

- **Hybrid Systems**
  - Biological Denitrification
    - Fixed Bed
    - Fluidized Bed
    - MBR/MBfR
  - Chemical Denitrification
    - ZVI
    - SMI
    - Other Media

- **Nitrate Reduction**
Available Treatment Technologies

Evolutionary Technologies

**Biological**
- Unreliable microbial activity
- Microorganism loss
- Sludge production
- Large footprint

**Physical**
- Secondary waste streams
- N/A for all contaminants
- High energy usage
- Large footprint

**Chemical**
- Expensive consumables
- Secondary waste streams
- N/A for all contaminants
- Post treatment needed

**Membrane Bioreactor**
- Frequent fouling (short lifespan)
- Sludge production
- N/A for all contaminants

*HIGH LIFECYCLE COST*
Power of Biology

“Biology is the most ancient and most powerful technology that we know of. It can do things that no other man-made machine or synthetic chemistry can even begin to approach in terms of the materials it can create and the functions that it can do”

Dr. Alicia Jackson, Deputy Director DARPA
Fundamental Challenges with Biology

The conventional paradigm for biological water/wastewater treatment is based on repeatedly growing and then removing microorganisms.

- **Unreliable**
- **Energy Intensive**
- **Large Footprint**
- **Wasteful**
- **Inefficient**
- **Costly**
Microvi’s MicroNiche Engineered Approach

**Traditional Biological Treatment**

**Microvi MicroNiche Engineered Approach**

Utilizes only the most active, effective microbes (●) in combinatorially engineered microenvironments
Microvi Solution & Sunny Slope Project
Wells 11 & 12 from Raymond Basin have nitrates over the MCL
Current treatment included blending wells 11 & 12 with water from the San Gabriel Main Basin
No MET connection

Under-pumping from wells 11 & 12; leaving a large volume of annual allotment in the ground
Over-pumping from San Gabriel Main Basin; paying tier 2 prices
No access to “brine” line

Looking for a Nitrate treatment solution that is cost effective and does not produce a waste stream
Microvi partners with Sunny Slope to get treatment system permitted by Division of Drinking Water

<table>
<thead>
<tr>
<th>Phase I - Small Pilot (2 gpm)</th>
<th>Phase II - DDW Demonstration (25 gpm)</th>
<th>Phase III - Full Scale System (Treating 1,300 gpm well)</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Consistent Nitrate Removal</td>
<td>▶ Consistent nitrate removal</td>
<td>▶ Produce drinking water effluent water quality</td>
</tr>
<tr>
<td>▶ No/minimal waste stream</td>
<td>▶ Response to process upsets</td>
<td>▶ Consistent nitrate removal</td>
</tr>
<tr>
<td>▶ Fast retention time</td>
<td>▶ Produce drinking water effluent water quality</td>
<td>▶ 50% cost savings over other treatment options</td>
</tr>
<tr>
<td>▶ Ease of operation</td>
<td>▶ Process optimization</td>
<td>▶ Design, Build, Own, and Operate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Obtain full permit</td>
</tr>
</tbody>
</table>

Consistent nitrate removal
Response to process upsets
Produce drinking water effluent water quality
Process optimization
Obtain DDW conditional acceptance

Produce drinking water effluent water quality
Consistent nitrate removal
50% cost savings over other treatment options
Design, Build, Own, and Operate
Obtain full permit
# Phase II – DDW Demonstration Summary

## Steady State
- Nitrate
- Taste & Odor
- 5 – day Simulated TTHM

## Flow Interruption
- Short-Term (1 hour) Shutdown
- Medium-Term (8 hour) Shutdown
- Long-Term (2 day) Shutdown

## 100% Chemical Interruption
- Short-Term (1 hour) Shutdown
- Medium-Term (8 hour) Shutdown
- Long-Term (2 day) Shutdown

## 50% Chemical Interruption
- Short-Term (1 hour) Shutdown
- Medium-Term (8 hour) Shutdown
- Long-Term (2 day) Shutdown

<table>
<thead>
<tr>
<th>Analytes</th>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>HACH LDO</td>
<td>&gt; 3mg/L</td>
</tr>
<tr>
<td>Nitrate</td>
<td>HACH Nitratax Plus SC</td>
<td>&lt; 5 mg/L</td>
</tr>
<tr>
<td>Turbidity</td>
<td>1720E Turbidimeter</td>
<td>&lt; .30 NTU</td>
</tr>
<tr>
<td>Heterotrophic Plate Count (HPC)</td>
<td>SM 9215B</td>
<td>2 CFU/ml</td>
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<tr>
<td>E. Coli Bacteria</td>
<td>SM 9223</td>
<td>Absent</td>
</tr>
<tr>
<td>Total Coliform Bacteria</td>
<td>SM 9223</td>
<td>Absent</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>EPA 524.2</td>
<td>Non-Detect</td>
</tr>
<tr>
<td>Bromoform</td>
<td>EPA 524.2</td>
<td>Non-Detect</td>
</tr>
<tr>
<td>Chlorodibromomethane</td>
<td>EPA 524.2</td>
<td>Non-Detect</td>
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<tr>
<td>Chloroform</td>
<td>EPA 524.2</td>
<td>0.83 μg/L</td>
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<tr>
<td>Total THM</td>
<td>EPA 524.2</td>
<td>0.83 μg/L</td>
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<tr>
<td>Haloacetic Acids Formation Potential (HAA5)</td>
<td>EPA SM 6251B/5710A/5710B</td>
<td>Non-Detect</td>
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<tr>
<td>5 Day Simulated Total TTHM</td>
<td>EPA 524.2</td>
<td>3.7 μg/L</td>
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<tr>
<td>Geosmin (Taste &amp; Odor)</td>
<td>EPA SM 6040E</td>
<td>Non-Detect</td>
</tr>
<tr>
<td>Methylisobomeol (Taste &amp; Odor)</td>
<td>EPA SM 6040E</td>
<td>Non-Detect</td>
</tr>
</tbody>
</table>
The Denitrovi™ Process at Sunny Slope

GAC Effluent

Feed Tank

Carbon Dosing

Denitrovi™ Nitrate-Removal Process

Denitrovi Reactor

Aeration Tank

Ultrafiltration System

Chlorine Contact Tank

Sunny Slope Reservoir

Sodium Hypochlorite Dosing

Microvi's Proprietary Biocatalysts

Raw Water

Clean Water

Microvi-Designed Reactor
Phase III – Full Scale System

- **Confirm** Phase II results and effluent water quality with full scale system for DDW
- **Obtain** full permit from DDW (mid – April) and begin discharging to Sunny Slope Reservoir
- **Optimization** of treatment process

<table>
<thead>
<tr>
<th>Parameter</th>
<th># Samples</th>
<th>Results</th>
<th>Average</th>
<th>Limit</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Heterotrophic Plate Count</td>
<td>9</td>
<td>ND</td>
<td>-</td>
<td>500</td>
<td>CFU/mL</td>
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<tr>
<td>Total Coliform</td>
<td>9</td>
<td>ND</td>
<td>-</td>
<td>0 (ND)</td>
<td>MPN/100 mL</td>
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<tr>
<td>Haloacetic Acids</td>
<td>3</td>
<td>ND</td>
<td>-</td>
<td>60</td>
<td>ug/L</td>
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<tr>
<td>Total Trihalomethanes</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>80</td>
<td>ug/L</td>
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<tr>
<td>Total Dissolved Solids</td>
<td>3</td>
<td>330</td>
<td>-</td>
<td></td>
<td>mg/L</td>
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<tr>
<td>Total Alkalinity</td>
<td>3</td>
<td>150</td>
<td>-</td>
<td>mg/L as CaCO₃</td>
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<tr>
<td>Calcium</td>
<td>3</td>
<td>50</td>
<td>-</td>
<td>mg/L</td>
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<tr>
<td>Nitrate (grab sample)</td>
<td>3</td>
<td>1.8</td>
<td>-</td>
<td>10</td>
<td>mg/L as N</td>
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<tr>
<td>Nitrate (Online)</td>
<td>948</td>
<td>-</td>
<td>1.3</td>
<td>10</td>
<td>mg/L as N</td>
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<tr>
<td>pH (Online)</td>
<td>789</td>
<td>-</td>
<td>6.68</td>
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<tr>
<td>Temperature (Online)</td>
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<td>74.9</td>
<td>°F</td>
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<td>Turbidity (Online)</td>
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<td>-</td>
<td>0.03</td>
<td>0.3</td>
<td>NTU</td>
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<tr>
<td>Dissolved Oxygen (Online)</td>
<td>948</td>
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<td>4.2</td>
<td>mg/L</td>
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<td>Free Chlorine (Online)</td>
<td>786</td>
<td>-</td>
<td>1.74</td>
<td>mg/L</td>
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</tbody>
</table>
Microvi and Sunny Slope pave the way for cost effective nitrate treatment in California

- Over 50% operational savings for Sunny Slope
- Achieved rigorous CA Division of Drinking Water (DDW) and NSF 61 certifications
- Treating 1,200 gpm nitrate contaminated well
- Key Partners Include:
  - Ken Tcheng - SSWC
  - Troy Holland - SSWC
  - David Byrum - CivilTec
  - Eric Hoopes - IntuiTech
  - California Division of Drinking Water