Direct Potable Reuse Demonstration in San Francisco

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San Francisco Water Supplies

- San Francisco has historically relied on the Regional Water System
- Since 2008, the SFPUC has begun to diversify and implement traditional and non-traditional alternative water supplies
Diversifying Water Supplies in SF

Traditional Alternative Sources

Recycled water irrigation at Harding Park Golf Course

Non-Traditional Alternative Sources

Groundwater
Diversifying Water Supplies in SF

Our Next Step:
Begin the process of evaluating the feasibility of direct potable reuse as part of San Francisco’s water supply portfolio.

PureWaterSF
Evaluate Building-Scale Treatment

- Demonstrate at a – building scale – the capability to treat the wastewater onsite to achieve water quality that would be suitable for augmenting drinking water supplies
PureWaterSF Project Details

- Pilot system design and operation by SFPUC and Carollo
- Pilot system components:
  - UF: WesTech with Toray
  - RO: Evoqua
  - UV (AOP): Xylem
  - Online Monitoring: s::can
- Analytics
  - Southern Nevada Water Authority
  - UC Davis
  - BioVir
  - Eurofins
PureWaterSF Project Details

- **SMALL** Equipment that Acts **BIG**:
  - Fully automated control systems
  - Complete with CIPs and chemical feed systems
  - Transparent piping to showcase water quality
PureWaterSF Demonstration Room - Pre-Installation
PureWaterSF Demonstration Room

UF

RO

UV
Online Monitoring – s::can micro::station

<table>
<thead>
<tr>
<th>Parameters</th>
<th>RO Feed</th>
<th>RO Permeate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloramines</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Free Chlorine</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Total Organic Carbon (TOC)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Dissolved Organic Carbon (DOC)</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>UVA at 254 nm</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Nitrate</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Nitrite</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td>✔️</td>
</tr>
</tbody>
</table>
Challenges of Building-Scale Treatment

• Small footprint
  • Redundancy
  • Chemical storage

• Cost
  • Customized equipment

• Operation
  • More variability
  • Low RO recovery rate

• Safety
  • Chemical storage
Importance of Risk Assessment for PureWaterSF

Demonstrates reliability and risk of advanced water treatment systems at a building scale

- Characterizing advanced treatment performance
- Pathogen monitoring of raw wastewater
  - Different than municipal-scale wastewater
  - Variable – seasonal
- Demonstrate monitoring technologies reliability
Importance of Risk Assessment for PureWaterSF

Adds to growing body of data to help fill research gaps in statewide efforts, as recommended by the Expert Panel.

- Approach to address public health risk of these treatment systems aligns with the statewide framework for potable reuse
  - QMRA is the underlying framework for how pathogen treatment requirements are being developed for CA
  - Already existing treatments for groundwater, etc.
  - QMRA where numbers came from for DPR and where they mostly will come from.

- This understanding will inform SFPUC understanding of how QMRA standards are developed.
Quantitative Microbial Risk Assessment (QMRA)

- A tool to characterize risks associated with pathogens, and demonstrates the effectiveness of various advanced treatment technologies
  - Monte Carlo Simulation
What Information Does QMRA Need?

- Raw Wastewater (18 samples – bimonthly)
  - Norovirus (GIA, GIB, GII)
  - Enterovirus
  - Adenovirus
  - *Giardia*
  - *Cryptosporidium*
What Information Does QMRA Need?

Pathogen concentrations in DPR source water + Unit process performance data = Daily risk of infection for target pathogens
Preliminary Performance Data

UF demonstrates 4 to 5 LRV of both Giardia and Cryptosporidium
Average LRV = 4.59
5th percentile = 4.36

Stable operation of RO over the last 9 months
Recovery rate = 47%
EC Average LRV = 1.17
5th percentile = 1.01
TOC online monitoring preliminary results

Average LRV = 1.52
5\textsuperscript{th} percentile = 1.41
What Information Does QMRA Need?

- Pathogen concentrations in DPR source water
- Unit process performance data
- Daily risk of infection for target pathogens

![Graph showing daily risk of infection for different pathogens](image)
Trace and unknown chemicals and Bioassays also under investigation

**Bioassays**
- Estrogen like chemicals
- Glucocorticoid / progesterone like chemicals
- Androgen like chemicals
- Dioxin like chemicals
- Genotoxicity
- Cytotoxicity

**Trace Level Chemical Pollutants**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Criterion</th>
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<tbody>
<tr>
<td>Perfluorooctanoic acid (PFOA)</td>
<td>0.4 µg/L</td>
</tr>
<tr>
<td>Perfluorooctane sulfonate (PFOS)</td>
<td>0.2 µg/L</td>
</tr>
<tr>
<td>Perchlorate</td>
<td>15 µg/L</td>
</tr>
<tr>
<td>1,4-Dioxane</td>
<td>6 µg/L</td>
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<tr>
<td>Ethynyl Estradiol</td>
<td>1 µg/L</td>
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<tr>
<td>17β-estradiol</td>
<td>Detection limit</td>
</tr>
<tr>
<td>Cotinine/Primidone/Dilantin</td>
<td>1/10/2 µg/L</td>
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<tr>
<td>Meprobamate/Atenoloid</td>
<td>Detection limit</td>
</tr>
<tr>
<td>Carbamazepine</td>
<td>1000 µg/L</td>
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<tr>
<td>Estrone</td>
<td>320 ng/L</td>
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<tr>
<td>Sucrose</td>
<td>150 mg/L</td>
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<tr>
<td>3,3'-di-chloroethylphosphate (TCP)</td>
<td>5 µg/L</td>
</tr>
<tr>
<td>N,N-diethyl-meta-toluamide (DEET)</td>
<td>200 µg/L</td>
</tr>
<tr>
<td>Triclosan</td>
<td>2100 µg/L</td>
</tr>
</tbody>
</table>

* Reproduced from Trussell et al., 2013.
Summary

• UF and RO performed as expected during the operation

• Ongoing sampling
  • Raw Wastewater Pathogen
  • CECs
  • Bioassays
  • UVAOP Challenge Test

• Next Steps
  • Data Analysis and QMRA
Acknowledgments

• SFPUC staff
• Project team
• Funding partners

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Thank you!

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Living Machine™ at SFPUC Headquarters

• Constructed wetland
  • 5,000 gpd
  • Meets Title 22 Recycled Water Regulations
  • 60% reduction of water use in the building
  • Reuse for toilet flushing

525 Golden Gate Avenue, San Francisco

Living Machine™ Treatment Process

1. Trash & Settling Tank
2. Equalization & Recirculation Tank
3. Screen Filter
4. Tidal Flow Wetland
5. Vertical Flow Wetland
6. Cartridge Filter
7. Chlorine Feeder
8. UV Light

Source Water
Non-potable water used for toilet and urinal flushing
Living Machine Treatment Train

Living Machine™ at SFPUC HQ

PureWaterSF Objectives

- Demonstrate at a – *building scale* – the capability to treat the wastewater onsite to achieve water quality that would be suitable for augmenting drinking water supplies
- Demonstrate monitoring technologies reliability
- Provide data to help fill in current gaps in statewide efforts
- Deliver a community-focused education and outreach program on purified water to strengthen connection between technical results and public acceptance
PureWaterSF Pilot Schematic
PureWaterSF Outreach and Education

- On Site Tours
- Video Tour
- Website
- Digital Wall
- Educational Materials