Neutralization Optimization
Minneapolis Water Works

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University of Minnesota
Driven to Discover℠
Facility Background

• Minneapolis Water provides tap water to Minneapolis and surrounding communities

• Produces ~57 million gallons of water per day

• Columbia Heights Membrane Plant
  • Ultrafiltration to remove impurities
  • Uses hollow fiber membranes
Project Background: Backwashes

• Backwashes clean filters

• 2 types of chemically enhanced backwashes (CEB)
  • CEB1: Sodium hypochlorite (bleach)
    • Sterilizes filter membranes
  • CEB2: Sodium bisulfite (SBS) and hydrochloric acid (HCl)
    • Removes fouling, particularly ferric chloride coagulant
Project Background: Neutralization

- Chemical backwashes produce waste
- Neutralization process:
  - Completely automated
  - Waste is sent to neutralization tank after backwash
  - Raw chemicals added to neutralize harmful reactions
  - Neutralized waste eventually added back in Mississippi River
- Limits:
  - pH = 5.4-8.8
  - ORP = 200-500 mV
Motivations for Change

- $30,000 a year on neutralization chemicals
- More neutralization chemicals means more salts in the water
- Salts a concern, though discharge is within permit
- 40,000 lbs Na+ per year added to water from neut chems

Annual Neutralization Chemical Use (thousands of gallons)
Project Overview

• **Goal:** to Reduce Raw Chemicals Used in Neutralization

• **Areas of interest:**
  
  • **Major:**
    • Self-neutralization – complete
  
  • **Minor:**
    • Tank mixing – complete
    • Sources of variability in neutralization – complete
    • Re-examine ORP limits – progress, incomplete
Self-Neutralization

• CEB2 (sodium bisulfite and HCl) always followed by CEB1 (bleach)
• Currently, each wash is neutralized separately
• Self-Neutralization
  • Add CEB2 and CEB1 together to partially neutralize before adding raw chemicals
Current Method:

1. **Neutralization Tank “A”**
   - **Input**: CEB1 (bleach), SBS, NaOH
   - **Output**: Neutralized Waste

2. **Neutralization Tank “B”**
   - **Input**: CEB2 (SBS), Neutralized Waste
   - **Output**: Neutralized Waste

**Key Chemicals**:
- SBS
- NaOH
- Bleach
Self-Neutralization:

Neutralization Tank “A”

- CEB2 (SBS)
- CEB1 (Bleach)

Input:
- SBS
- NaOH

Output:
- Neutralized Waste
Findings

• Full scale tests succeeded
  • Reduces raw chemical demand
  • Requires no new equipment
  • Requires a self-neutralization routine to be programmed

• Around 1,500 self-neutralizations per year possible

• Savings: $12,000 a year

Annual Chemical Use (thousands of gallons)

- **NaOH**
  - Currently Used
  - Used with Self-Neut

- **SBS**
  - Currently Used
  - Used with Self-Neut

- **Bleach**
  - Currently Used
  - Used with Self-Neut
## Findings: Summary

<table>
<thead>
<tr>
<th>Waste reduction option</th>
<th>Change Type</th>
<th>Waste reduced (per year)</th>
<th>Implementation cost</th>
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<td>Self-Neutralization Procedure change</td>
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<td>34,000 lbs SBS 80,000 lbs Bleach 26,000 lbs NaOH</td>
<td>$2,200</td>
<td>$12,000</td>
<td>2.2 months</td>
<td>Planned 2018</td>
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Tank Mixing

• Mixing a concern with self-neutralization
  • Two batches at once = larger volume to mix
Findings

• Mixing appears adequate
  • Surface visibly disturbed by mixing
  • Measurements relatively constant as tank empties

• Self-neutralization requires more mixing time
  • ~6 min for pH to stabilize, much longer for ORP
  • 10 minutes recommended to mix self-neut batch

• Recommendation: Perform maintenance on system to ensure no blockages
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<td>Procedure change</td>
<td>430 lbs SBS, 300 lbs Bleach, 290 lbs NaOH</td>
<td>$800</td>
<td>$90</td>
<td>8.9 years</td>
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Sources of Variability

• With more consistency, more efficiency is possible

• No correlations between initial and final conditions found
  • Tank Level
  • Unit distance from neut tank
  • Starting ORP and pH in tank

• Potential source:
  • Pumps for same chemical calibrated differently

• Recommendation: Recalibrate pumps, particularly bleach and NaOH
## Pump Recalibration Summary

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<td>Procedure change</td>
<td>4,000 lbs NaOH</td>
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Future Work

• Continue investigating ORP
  • Determine new limits?
  • Changes in ORP from exposure to air?

• Follow-up on pump recalibration
Personal Benefits

- Balancing independent work vs asking for help
- Planning steps toward a complex goal
- Designing experiments
- Learning to get the information I need from the data I have
Questions?