EFFECTS OF WATER SOFTENER BACKWASH ON ONSITE WASTEWATER SYSTEMS

Chris Kinsley, Ph.D., P.Eng. & Anna Crolla, Ph.D., P.Eng.
Study Objectives

Primary
• Evaluate the impact of water softener backwash on the physical and biological treatment occurring in septic tanks under field conditions

Secondary
• Observe any impact of water softener backwash on septic tank corrosion
• Observe any impact of water softener backwash on leaching bed performance
How a Water Softener Works

Credit: Pipeline, Winter 2001, National Small Flows Clearinghouse
How a Water Softener Works

• Water softeners remove hardness (Ca++, Mg++)
• Resin regeneration with NaCl occurs 1-2 times/week
  • Time clock (inefficient)
  • Demand Initiated Regeneration (DIR) (demand based)
  • 190 L/backwash
What are the Potential Impacts of Water Softeners on Onsite Systems?

General
• Hydraulic loading

Septic Tank
• Salt toxicity to anaerobic microbes
• Concrete corrosion
• TSS settleability

Aerobic Treatment Units
• Salt toxicity to aerobic microbes / warranty

Leaching Bed
• Permeability in clay soils
What are the Potential Impacts of Water Softeners on Onsite Systems?

• Hydraulic loading
  • Water softener backwash discharges up to **190L once or twice a week**. Volume is similar to that of a washing machine.
    ➢ *Hydraulic loading is not an issue.*

• Septic tank - microbial toxicity
  • Sodium is moderately harmful to anaerobic bacteria at 3.5 to 5.5 g/L and very harmful at 8 g/L (Roberts Alley, 2000).
  • Inhibition of methanogenic bacteria was only encountered at 65 g/L Na Cl (de Baere et al, 1984)
  • Sodium in STE receiving water softener backwash was 0.3 ± 0.2 g/L (Tyler *et al*, 1977)
    ➢ *Highly unlikely that water softener backwash is impacting anaerobic digestion.*
What are the Potential Impacts of Water Softeners on Onsite Systems?

• Septic tank - Corrosion
  • \( \text{H}_2\text{S} \) converts to sulphuric acid (\( \text{H}_2\text{SO}_4 \)) under contact with oxygen and is the primary cause of concrete corrosion
  • It is possible that hard water may contain more sulphur leading to more corrosion potential in concrete tanks receiving WS backwash.
  ➢ WS backwash is not responsible for tank corrosion.
What are the Potential Impacts of Water Softeners on Onsite Systems?

- Septic tank - TSS settleability
  
  “Studies with septic tanks, which are designed to be quiescent by nature, have shown that the high concentration of salt introduced by slugs of backwash brine cause salt stratification in the tank, which inhibits the ability of solids and FOG to stratify.” (Gross and Bounds, 2007)
What are the Potential Impacts of Water Softeners on Onsite Systems?

- Septic tank - TSS settleability
  - A major study was sponsored by the WQRF in 2012 including column tests to simulate septic tanks and field studies

Environmental Impact Study:
- Water Softener Effects on Septic System Performance

The study of Water Softener Effects on Septic System Performance was conducted through the Virginia Polytechnic Institute and State University, funded by the Water Quality Research Foundation, and reported in 2013.
What are the Potential Impacts of Water Softeners on Onsite Systems?

- Septic tank - TSS settleability

**Experimental Treatment of Columns**
- Control 1 (No Softening)
- Control 2 (No Regen)
- Low Na Level (≤4000 gr/lb)
- Moderate Na Level (≤2000 gr/lb)
- High Na Level (≤1000 gr/lb)

**BOD (mg/L)**
- Controls
- Regen Aided

**VSS (mg/L)**
- Controls
- Regen Aided

**Avg. Solids (mg/L)**
- Tank 1 (Receiving Regenerant)
- Tank 2 (No Regenerant Received)
What are the Potential Impacts of Water Softeners on Onsite Systems?

- Septic tank - TSS settleability / density stratification

  Major Study Findings:

  1. The addition of regeneration wastes that contain Ca\(^{++}\), Mg\(^{++}\) and Na\(^{+}\) from efficiently operated DIR water softeners (> 2000 gr/lb) has been found to help in the settling of solids and to produce a better quality effluent. *NOTE:* NSF/ANSI standard 44 efficiency rated water softeners must have a rated efficiency of at least **3350 gr/lb**.

  2. Adding the regenerant to the septic tank yields lower TSS and VSS in the effluent. Furthermore, diversion of regeneration wastes away from the septic tank may result in an effluent that is poorer in quality.

➢ Addition of WS backwash to septic tanks from well operated WS systems does not impact tank performance.
What are the Potential Impacts of Water Softeners on Onsite Systems?

- **Aerobic Treatment Units – Salt Toxicity & Warranty**
  - NSF Study in 1978 “The Effect of Home Water Softener Waste Regeneration Brines on Individual Aerobic Wastewater Treatment Plants” found that water softener waste improve biological action and reduce BOD in aerobic systems.
  - Recent study by Novak found that an imbalance of monovalent to divalent (M/D) cation ratio of >3 (Na : Ca+Mg) can lead to poor settling. This threshold corresponded to < 3000 gr/lb.
  - Older inefficient WS units could lead to reduced settling in aerobic treatment units.
  - If warranty is an issue then a possible solution would be to bypass the septic tank and ATU with the WS discharging directly to the leaching bed.
What are the Potential Impacts of Water Softeners on Onsite Systems?

• Leaching bed permeability in clay soils
  - Sodium can cause clay to swell and possibly reduce the hydraulic conductivity in the leaching bed.
  - A study by the University of Wisconsin-Madison found no impact upon soil hydraulic conductivity and that Ca and Mg counteracted the impact of Na (Cory *et al*, 1977).

➢ Regen water **should not** be diverted away from the septic field.
Our Study

- 75 Residential Septic Tanks Sampled
  - 5 with water softeners regeneration diverted from tank
  - 22 with water softener backwash to the tank
  - 48 without water softener

- Samples collected by René Goulet (local pumper) using a Sludge Judge™
Methodology

• 2 L sludge samples taken from top 10 cms of sludge
• 1 L effluent samples taken at the outlet T
• An inspection form was filled in by René Goulet and the homeowner
<table>
<thead>
<tr>
<th>Date</th>
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<table>
<thead>
<tr>
<th>Location Information</th>
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<tbody>
<tr>
<td>Name</td>
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<td>Address</td>
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<table>
<thead>
<tr>
<th>Tank Information</th>
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<tbody>
<tr>
<td>Tank Type</td>
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<tr>
<td>Tank Size</td>
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<tr>
<td>Tank Age</td>
</tr>
<tr>
<td>Condition of tank</td>
</tr>
<tr>
<td>Date of last tank pump-out</td>
</tr>
<tr>
<td>Sludge + scum depth (cm)</td>
</tr>
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<table>
<thead>
<tr>
<th>Water Softener Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a water softener being used</td>
</tr>
<tr>
<td>Is water softener being discharged to septic tank</td>
</tr>
<tr>
<td>Type of salt</td>
</tr>
<tr>
<td>Amount of salt used (kg/month)</td>
</tr>
<tr>
<td>Backwash Cycle (L/cycle, cycles/day)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Water Use Information</th>
</tr>
</thead>
<tbody>
<tr>
<td># of people in house</td>
</tr>
<tr>
<td># of bedrooms</td>
</tr>
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<table>
<thead>
<tr>
<th>Drainage Field Information</th>
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<tbody>
<tr>
<td>Type of system</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Age of system</td>
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<tr>
<td>Signs of problems</td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td>Type of soil</td>
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</table>
Statistical Analysis

• The data was divided into three groups (no regen water, with/without water softener backwash) to compare the effect of NaCl on tank performance
  • Sludge: Na, HPC, TS, sludge and scum accumulation rates.
  • STE: CBOD$_5$, TSS
## Results

Table 1. Septic Tank Sample Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Water Softener with Backwash Water Diverted</th>
<th>Water Softener with Backwash Water</th>
<th>No Water Softener</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (Range)</td>
<td>Median (Range)</td>
<td>Median (Range)</td>
<td></td>
</tr>
<tr>
<td>Number of Tanks</td>
<td>Number</td>
<td>5</td>
<td>22</td>
<td>48</td>
</tr>
<tr>
<td>Tank Volume</td>
<td>Litres</td>
<td>3600 (3600-5400)</td>
<td>3600 (2700-5400)</td>
<td>3600 (1800-5400)</td>
</tr>
<tr>
<td>Tank Age</td>
<td>Years</td>
<td>25 (15-40)</td>
<td>20 (5-40)</td>
<td>21 (2-40)</td>
</tr>
<tr>
<td>Number of Inhabitants</td>
<td>Persons</td>
<td>3 (1-5)</td>
<td>3 (1-5)</td>
<td>3 (1-6)</td>
</tr>
<tr>
<td>Time Since Last Pump-out</td>
<td>Years</td>
<td>3 (1-7)</td>
<td>5 (2-19)</td>
<td>4 (0.5-20)</td>
</tr>
</tbody>
</table>
Effects of Water Softeners on Septic Tank Sludge

- Sodium is moderately inhibitory to anaerobic bacteria at 3500-5500 mg/L and is highly inhibitory at 8000 mg/L (Roberts Alley, 2000)
Effects of Water Softeners on Septic Tank Sludge

- No Differences in Hetertrophic Plate Count suggests no effect of salt on bacteria in sludge
Effects of Water Softeners on Septic Tank Sludge

- No differences between no WS and WS/BK, possible effect with BK diversion reducing sludge density and increasing volume
Effects of Water Softeners on Septic Tank Effluent

- No effect on cBOD5 concentrations in STE
Effects of Water Softeners on Septic Tank Effluent

- No significant effect of WS on TSS (high variation in samples)
Does Chloride Affect Tank Corrosion?

Figure 1. Corroded Outlet Baffles of two Tanks Receiving Water Softener Backwash – Does chloride accelerate the corrosion caused by $\text{H}_2\text{S}$ gas?
Table 3. Effect of Water Softener Brine on Tank Corrosion

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>WS</th>
<th>NWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Age (Range)</td>
<td>Years</td>
<td>20 (5-40)</td>
<td>20 (2-40)</td>
</tr>
<tr>
<td>Number of Tanks</td>
<td>Number</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>Number of Corroding Outlet Baffles</td>
<td>Number</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Portion of Tanks with Corroded Outlet Baffle</td>
<td>%</td>
<td>38</td>
<td>23</td>
</tr>
</tbody>
</table>

- The primary agent of concrete tank corrosion is sulphuric acid derived from hydrogen sulphide gas.
- Cl⁻ from water softener backwash could play a role in accelerating the corrosion of reinforced concrete tanks by contributing to the corrosion of the re-bars.
Does Sodium Affect Leaching Bed Permeability?

- 12 of 75 systems experiencing hydraulic failure
  - Surface breakout (2 systems)
  - High water level in tank (10 systems)
- 0 of 12 failing systems receiving water softener backwash
- 9 of 12 failing systems in clay soils
  - 41% of systems installed in a clay soil in a mode of failure
  - 3% of systems not installed in a clay soil in a mode of failure
- Failed systems 10-40 years old
  - Median age of failed systems 27 years
  - Median age of functioning systems 20 years
Conclusions

Water softener backwash discharged to septic tanks has no significant effect upon the biological or physical functioning of the tank.
Conclusions

1. There were significant differences in the sodium and chloride concentrations
   • Sodium concentrations were lower than inhibition levels of anaerobic bacteria

2. There were no significant differences in indicators of tank performance
   • STE: COD, CBOD$_5$, TSS, *E.coli*
   • Sludge: TC, VSS and solids accumulation rate

3. 12 of the 75 systems evaluated were experiencing hydraulic failure.
   • clay soils (9 out of 12 systems) and system age (median of 27 years) were determinant factors of failure.
   • none of the failed systems were receiving water softener backwash.
Acknowledgements

- René Goulet Septic Tank Pumping
- Canada Mortgage and Housing Corporation