Environmental Impact Study: Effects of Water Softener on Septic Tank Performance

Mark Unger – WQA Technical Manager
Overview

• Background information

• WQRF study set up and results
Background Information
• 85% of US water is considered hard

• US EPA estimates
  – Softener installations at ~10 million
  – Septic systems in 26 million existing homes
  – Septic systems in 40% of new homes
What is a water softener?

- Cation exchange resin
- Removes hardness ions (Ca$^{++}$, Mg$^{++}$, etc)
- Also removes most metallic ions such as Iron, Lead, Barium, Radium, Mercury, etc
- Whole house installation, regenerates by demand or time
Time Clock vs DIR

- Time Clock – regenerates based on time
- DIR – regenerates based on demand
- Regeneration spans 1-2 hrs
- Regenerations occurs <1 - 2 times per week
Regeneration Process

20 gal + 7.5 gal + 7.5 gal + 15 gal = 50 gal

0 10 20 30 40 50 60 70

0 0.5 1.0 1.5 2.0 2.5

Back wash
Brine Draw
Slow Rinse
Fast Rinse

Time (minutes)

0 10 20 30 40 50 60 70

Water Quality Research Foundation

Water Quality Association
Salt Usage Per Year

- TC (2850 g/lb)
- DIR (2850 g/lb)
- DIR (3350 g/lb)
- DIR (4000 g/lb)
History

- 1970’s – unspecified septic failures noted and softeners being blamed

- Specified failures
  - Poor maintenance
  - Tree root infiltration
  - Unwanted objects in system
  - Hydraulic overloading
  - Driving or parking over system
Early Research

• Septic Tank/Water Softener “Potential Effects of Water Softener Use on Septic Tanks Soil Absorption On-Site Wastewater Systems”
  – University of Wisconsin-Madison

• “The Effect of Home Water Softener Waste Regeneration Brines on Individual Aerobic Wastewater Treatment Plants”
  – NSF International
Results from University of Wisconsin and NSF Studies

• Water softener waste stimulate **biological action** in anaerobic or aerobic systems.

• The **volume** and **flow rate** of softener wastes do not cause deleterious problems in anaerobic or aerobic systems.

• Discharge does not interfere with percolation and might improve soil **percolation**, in fine textured soils.
• Contentions still remained that softener discharges cause septic failures

• Reported issue was lack of defined layers in septic tanks

• Regulators still questioned whether restriction of discharges to septic tanks was necessary
History

• ~2000 – state bans in CT, OR, and TX

• 2003 – TX rescinded/revised ban

• 2009 – WERF water softener workshop
Recent Studies

• Creekwood, NC Study*
  – Investigated salt and solids stratification
  – Showed lower salt levels with DIR softeners
  – Systems functioned well regardless of discharge
  – Did not show variations in stratification

*participants – WQA, CIDWT, NOWRA
Recent Studies

- Novak et. al, VA Tech findings in regard to Industrial Aerobic Activated Sludge systems:
  - An imbalance in the monovalent to divalent (M/D) cation ratio can lead to poor settling
  - This had not been tested in anaerobic systems.
- Poor settling and lack of clear zones may be due to excessive sodium (M) in relation to calcium (D) and magnesium (D).
• Novak activated sludge research found that M/D ratio >3 could lead to poor settling

  – @ 4000 Grains/lb ~ 1.8 (DIR)
  – @ 3000 Grains/lb ~ 2.2 (DIR)
  – @ 2000 Grains/lb ~ 3.1
  – @ 1000 Grains/lb ~ 5.5 (Old TC)
  – @ 500 Grains/lb ~ 10 (Old TC)
Data Weaknesses

• The Creekwood study did not address
  – M/D cation ratios
  – Impact of M/D ratio on stratification
  – Effluent filter clogging

• Novak et. al research did not address residential anaerobic applications
WQRF Septic Study
Set up and results
Study Overview

• Researcher – Dr. Novak
• Funding – WQRF
• Steering Committee – WQA, NOWRA, NSF
• Question – How does softener discharge effect the M/D cation ratio and septic system performance?
Study Goals

Look at amount and capture of suspended solids

Illustration from www.genie.com

Look at ability to separate layers and quality of effluent
Study Design

- Develop column tests to simulate tanks
- Evaluate stratification and water quality
- Compare column studies to real world samples
Column Set up

Overlying Grease Layer

Input of water with different cation content

Septic Tank Solids

Overlying Water

Water Discharge (below grease layer)

Effluent Filter
Actual Column Set Up
March 28, 2012: BOD Evaluation

CIDWT BOD < 170 mg/L

BOD (mg/L)

Date

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)
March 28, 2012: TSS Evaluation

CIDWT TSS < 60 mg/L

- 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)
June 27, 2012: BOD Evaluation

CIDWT BOD < 170 mg/L

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)
June 27, 2012: TSS Evaluation

CIDWT TSS < 60 mg/L

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)
Column Study Conclusions

- DIR unit must be set at or above 2000 gr/lb
- Higher efficiencies may be required in areas with sodium or other monovalent ions above 200 ppm
Case Studies

• Samples for real world comparisons were collected in North Carolina and New York

• Batch anaerobic digestion studies
  – Sodium impact on degradation rates
  – Determine quality of the overlying water

• Evaluate chloride impact on nitrification
  – If insufficient information in literature
Case Study Design

- Field testing of redirection of discharge
  - The Aquasource Group Inc.
  - All water is softened, discharge to ST1 only
Effluent Filter Evaluations

Effluent filters shown visually loaded
NY Results

Avg. Solids (mg/L)

Tank 1 (Receiving Regenerant)

Tank 3 (No Regenerant Received)
Settling Evaluations

Comparison of solids settling in tanks in a NY site:

Tank receiving softener regen water on right versus a tank without on left
Case Study Conclusions

• Education in areas with vacation homes may be required (time clock)

• Diversion of discharge may decrease effluent quality
WQA Tools

- Executive summary and significant findings
- Regulatory toolkit
- M/D ratio calculator

Located in the members section at wqa.org
# M/D Ratio Calculator

## Influent Water Characteristics (Water Analyses Results)

1. Sodium = [Enter Na+ water analysis result in mg/liter]
2. Potassium = [Enter K+ water analysis result in mg/liter]
3. Total Water Hardness = [Enter hardness in gpg]

## Wastewater Characteristics (Influent Water above plus Average Household Waste Values)

4. Sodium = [Enter sodium mg/liter as CaCO₃]
5. Potassium = [Enter potassium mg/liter as CaCO₃]
6. Total Monovalent Cations = [Enter total monovalent cations mg/liter as CaCO₃]
7. Total Divalent Cations = [Enter total divalent cations mg/liter as CaCO₃]

## Water Softening Operational Salt Efficiency

8. Salt efficiency = [Enter efficiency in gr/lb] grains of water hardness / pound of NaCl salt

## M/D Cation Ratio (Calculated for Actual Operational Salt Efficiency)

#VALUE! A value of 5 or less minimizes potential septic system impacts
Influent Water Characteristics (Water Analyses Results)

i. Sodium = 17 in mg/liter
ii. Potassium = 8 in mg/liter
iii. Total Water Hardness = 20 gpg

Wastewater Characteristics (Influent Water above plus Average Household Waste Values)

iv. Sodium = 156.89 mg/liter as CaCO3
v. Potassium = 24.24 mg/liter as CaCO3
vi. Total Monovalent Cations = 181.13 mg/liter as CaCO3
vii. Total Divalent Cations = 398 mg/liter as CaCO3

Water Softening Operational Salt Efficiency

viii. Salt efficiency = 4000 grains of water hardness / pound of NaCl salt

M/D Cation Ratio (Calculated for Actual Operational Salt Efficiency)

M/D ratio is less than 5
### Influent Water Characteristics (Water Analyses Results)

1. Sodium = 17 mg/liter
2. Potassium = 8 mg/liter
3. Total Water Hardness = 342 mg/liter

### Wastewater Characteristics (Influent Water above plus Average Household Waste Values)

4. Sodium = 156.89 mg/liter as CaCO₃
5. Potassium = 24.24 mg/liter as CaCO₃
6. Total Monovalent Cations = 181.13 mg/liter as CaCO₃
7. Total Divalent Cations = 398 mg/liter as CaCO₃

### Water Softening Operational Salt Efficiency

8. Salt efficiency = 1000

### M/D Cation Ratio (Calculated for Actual Operational Salt Efficiency)

- M/D ratio: 5.610879397

M/D ratio is greater than 5
Acknowledgments

Researchers
Dr. John Novak
Patrick Hogan
Greg Holbrook
Miguel Miranda

Support
WaterRight
Canandaigua Lake Watershed Commission
George Barden
Blacksburg and Christiansburg Wastewater Treatment Plants
Doug Grove
The Zoeller Company
Doug Goldsmith

Project Steering Committee
DJ Shannahan
Bob Boerner
Steve Richards
Gary Hatch
Frank Brigano
Mark Brotman
Regu Regunathan
Dick Otis
Eric Casey
Matt Byers
Allison Blodig
Jerry Stonebridge
Nancy Deal
Marcia Degen
Tom Bruursema
Thank you!

Questions?