SPL ENVIRONMENTAL®

CASE STUDY

Tracing QAC-Related Toxicity in a Municipal Wastewater Facility

January 2026

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Subject: Investigation of recurring biological treatment failures caused by Quaternary Ammonium Compounds (QACs).

Executive Summary

A municipal wastewater treatment plant (WWTP) experiencing repeated biological crashes during holiday periods engaged in a forensic investigation to identify the root cause. Utilizing advanced HPLC-MS testing, the facility identified toxic slug loads of Quaternary Ammonium Compounds (QACs)—common disinfectants—originating from a specific industrial source. SPL Environmental supported the WWTP in their analytical research with sampling and analysis support.

This case study outlines the operational challenges, the limitations of traditional testing, the investigation methodology, and the data-driven results that allowed the facility to address the contamination.

1. **The Challenge:** *Recurring Biological Collapse*

    The subject of this study is a municipal WWTP with a permitted flow of 1.5 MGD and a total capacity of approximately 2.5 million gallons. The facility faced a critical operational challenge: periodic toxicity events that resulted in rapid biological crashes.

    Operational Symptoms:

    - **Timing:** Events correlated specifically with 3-day holiday weekends, notably the 4th of July and Labor Day.
    - **Biological Impact:** The plant experienced a decline in oxygen uptake, poor settleability, and a complete loss of nitrification and denitrification processes.
    - **Visual Indicators:** Operational staff observed the development of foam and the disappearance of microbiology.
    - **Recovery Cost:** Restoring the plant required reseeding with 40,000 gallons of sludge and took approximately two months to stabilize.

2. **The Suspect:** *Quaternary Ammonium Compounds (QACs)*

    Engineers hypothesized that the toxicity was caused by "slug loads" of QACs resulting from large-scale "clean-downs" at commercial or industrial facilities during holiday shutdowns.

    What are QACs? QACs are cationic surfactants widely used as antimicrobials in disinfectants, sanitizers, and cleaning products. They are effective because they disrupt

cell membranes. While common in household products like Lysol (0.1–0.2% concentration) or Clorox wipes, they are found in much higher concentrations in industrial sanitizers such as Oasis 146 (~10%) or Virex II 256 (~10%).

Impact on Wastewater Systems: QACs are persistent and pass through collection systems to the treatment plant. They are toxic to biological treatment processes, specifically inhibiting nitrifiers and heterotrophs.

- **Inhibitory Threshold:** Biological inhibition typically begins at approximately 5 mg/L.
- **Critical Failure:** Concentrations exceeding this threshold lead to biomass collapse and compliance risks.

3. **Methodology:** *Advanced Detection*

A significant hurdle in identifying QAC toxicity is the limitation of traditional testing. Traditional colorimetric methods are subject to numerous interferences, possess relatively high detection limits (mg/L), and fail to identify specific compounds, providing only a "total" count.

To overcome this, the investigation utilized a proprietary **HPLC-MS (High-Performance Liquid Chromatography–Mass Spectrometry)** at SPL.

- **Sensitivity:** Minimizes interferences with a Method Reporting Limit (MRL) of 10 ppb.
- **Specificity:** Capable of isolating 16 of the most common QAC compounds.

4. **Investigation and Source Tracing**

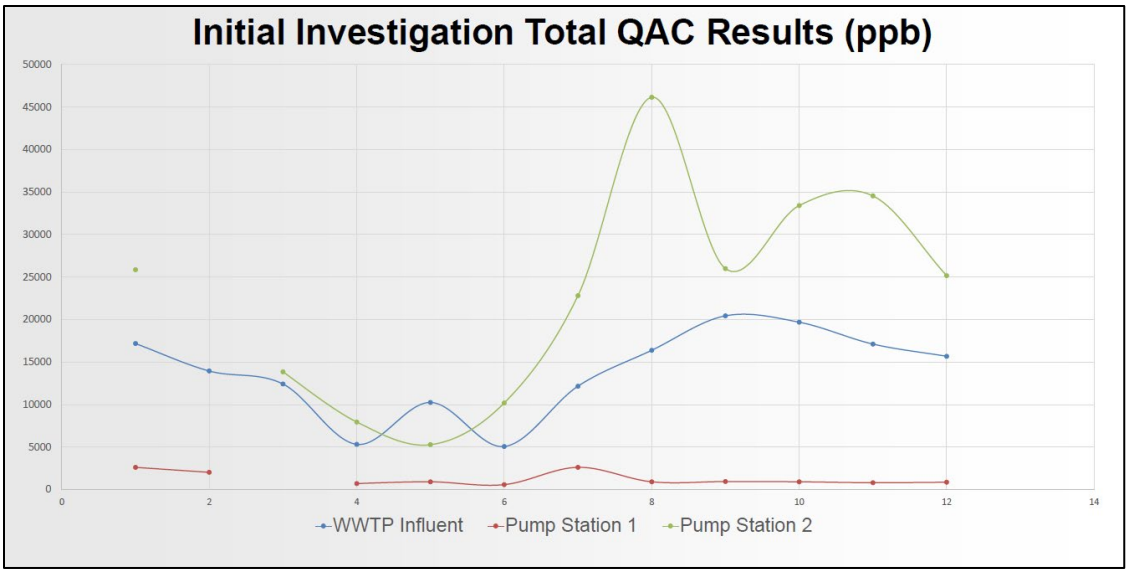
The investigation plan involved a 13-day sampling period covering the 4th of July holiday. The goal was to isolate the source by collecting 24-hour composite samples from the WWTP influent and two primary pump stations (PS1 and PS2). Note that Pump Station 2 collects flow from an area dense with restaurants and food production facilities.

Phase 1: Initial Findings (July 2025)

The results confirmed the hypothesis of toxic QAC concentrations far exceeding the 5 mg/L inhibitory threshold.

- **WWTP Influent:** Averaged 17 mg/L of QACs.
- **Pump Station 1:** Averaged only 1.5 mg/L.
- **Pump Station 2:** Averaged 24 mg/L, with spikes reaching **47.7 mg/L**.

Chemical Fingerprint: The specific compound driving the toxicity was identified as **Octyl Decyl Dimethyl Ammonium**.



Average Results by Analyte (ppb)

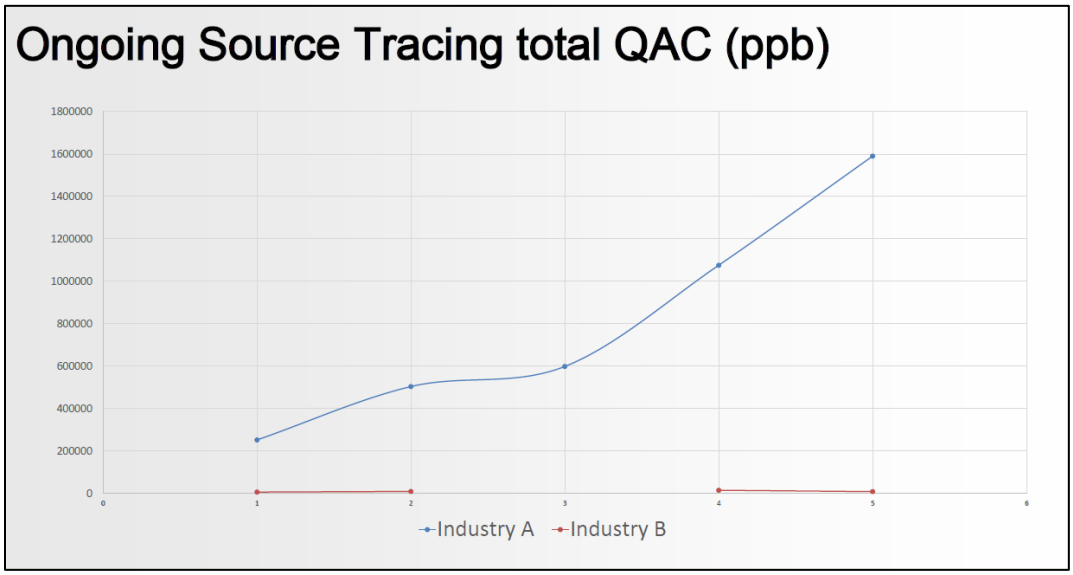
ANALYTE	Pump Station 1	Pump Station 2	WWTP Influent
Benzyldimethyldecylammonium	ND	ND	ND
Benzyldimethyldodecylammonium	17	131	76
Benzyldimethylhexadecylammonium	6	43	28
Benzyldimethyloctadecylammonium	4	6	4
Benzyldimethyloctylammonium	3	ND	ND
Benzyldimethyltetradecylammonium	21	196	125
Cetylpyridinium	ND	ND	ND
Didecyldimethylammonium	18	171	116
Didodecyldimethylammonium	ND	33	20
Dihexadecyldimethylammonium	ND	6	4
Dioctadecyldimethylammonium	17	13	18
Dioctyldimethylammonium	10	158	76
Ditetradecyldimethylammonium	ND	18	11
Octyldecyldimethylammonium	1267	22836	13805
Tetramethylammonium	ND	ND	ND
Tetrapropylammonium	ND	ND	ND

Phase 2: Industrial Source Identification (Labor Day 2025)

Following the initial findings, the investigation narrowed its focus to two major industries (Industry A and Industry B) discharging into the Pump Station 2 network. Direct sampling was conducted at discharge manholes over five days during the Labor Day holiday.

Results:

- **Industry B:** Showed negligible QAC levels (Octyl Decyl Dimethyl Ammonium at roughly 10,350 ppb, or ~10 mg/L).
- **Industry A:** Identified as the primary source. Samples revealed massive contamination, with Octyl Decyl Dimethyl Ammonium levels reaching **804,422 ppb (approx. 804 mg/L)**.
- **Other Compounds:** Industry A also discharged significant levels of Didecyldimethylammonium (~2,066 ppb) and Benzyldimethyldodecylammonium (~6,476 ppb).



Average Results by Analyte (ppb)

ANALYTE	Industry A	Industry B
Benzyldimethyldecylammonium	20	ND
Benzyldimethyldodecylammonium	6476	74
Benzyldimethylhexadecylammonium	230	13
Benzyldimethyloctadecylammonium	6	ND
Benzyldimethyloctylammonium	8	ND
Benzyldimethyltetradecylammonium	2734	66
Cetylpyridinium	ND	ND
Didecyldimethylammonium	2066	59
Didodecyldimethylammonium	ND	ND
Dihexadecyldimethylammonium	ND	ND
Dioctadecyldimethylammonium	ND	ND
Dioctyldimethylammonium	7711	70
Ditetradecyldimethylammonium	ND	ND
Octyldecyldimethylammonium	804422	10350
Tetramethylammonium	ND	ND
Tetrapropylammonium	ND	ND

5. **Conclusion and Solutions**

The investigation successfully linked the periodic biological crashes to holiday cleaning cycles at "Industry A," which released QAC concentrations nearly 160 times the inhibitory threshold of the treatment plant.

Strategic Outcomes: Currently, there is no federal EPA pretreatment program specifically for these compounds. However, the data-driven approach enabled the municipality to:

1. **Confirm Toxicity:** Verify that QAC levels were at harmful concentrations.
2. **Identify Sources:** Pinpoint the specific industrial discharger.
3. **Build a Case:** Support the implementation of pretreatment requirements or surcharge policies.

Recommendations for Mitigation: Facilities facing similar issues should consider working with sources to reduce chemical use or concentration, encouraging the switch to alternative cleaning products, or applying QAC neutralizers directly at the WWTP to protect the biomass.

For more information on sample collection or analysis of QACs, contact:
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