WASTEWATER CHLORINATION / DECHLORINATION MONITORING AND CONTROL PILOT DEMONSTRATION AT CITY OF GUELPH ONTARIO WWTF

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Background

- Regulatory limit for total residual chlorine (TRC), limit can be as low as 0.02 mg/l;
- Chlorination/de-chlorination disinfection is still widely used;
- Two critical process conditions:
  1. sufficient chlorine concentration at the end of contact chamber to maintain required Disinfectant CT Value; and
  2. sufficient de-chlor chemical dosage to minimize TRC.
- Common practice for dosing control:
  - Direct Chemical Analysis - Chlorine and Sulfite Analyzers
  - ORP Automation
  - Monitor residual sulfite as a surrogate to chlorine
  - Adjustment of set point by grab sample
Goal of Pilot Demonstration

• Demonstrate an ultra-low chlorine analyzer and sulfite analyzer suitable for chemical dosing control while meeting TRC requirement;
• Evaluate analyzer maintenance, reliability, and accuracy;
• Analyzer vs lab test
• Analyzer vs ORP probe
• Chlorine and Sulfite reaction time: to build a simulation loop allowing variable reaction time runs.
• Evaluate potential chemical saving
ChemScan mini- Analyzer

• Analyzer
  - Single sample line, single parameter
  - mini-LowChlor: 0.005 – 2.000 mg/l as Cl₂ at final discharge
  - mini-Dechlor: 0.01 – 4.00 mg/l de-chlorination as SO₃

• Accuracy
  - 2% of value or 2x detection limit (whichever greater)

• Sample Locations
  - Cl₂: secondary clarifier effluent, chlorine contact chamber outlet;
  - SO₃: final effluent

• Validation
  - Using potassium permanganate (KMnO₄), chemistry is stable then chlorine
Chlorine Data at Contact Chamber Outlet

Chlorine Analyzer and ORP Probe
(Jan 2 - Jan 19, 2015)
Simulation Loop Data

- Generate data on diffident reaction times
- Discover chlorine and sulfite relationship during dichlorination
- Optimized sulfite residual for 0.02 mg/l TRC
Simulation Loop Run
Reaction Time = 5 min
Oct 7 - 8, 2015

Chlorine/sulphite (mg/l)

Chlorine - Blue
Sulphite - Orange

Graph showing the chlorine and sulphite levels over time from Oct 7 to Oct 8, 2015.
Simulation Loop Run

Reaction Time = 7 min

September 23 - 24, 2015

Chlorine/sulfite (mg/l)

9/23/2015 to 9/24/2015

Chlorine: blue line
Sulfite: orange line
Simulation Loop Run

Reaction Time = 15 min

September 24, 2015

Chlorine/sulfite (mg/l)
Potential Chemical Savings

- Chemical dechlorination process can be difficult to control when near zero levels of residual chlorine are required;

- Conservative dosing of the chemicals to meet discharge limitation is not an uncommon occurrence with existing practices;

- The following hypothetical calculations are based on a flow rate of 25 MLD treatment plant to illustrate potential chemical savings:
  - Chlorination: 12% liquid sodium hypochlorite at $0.2 per liter
  - Dechlorination: 38% liquid sodium bisulfite at $0.4 per liter

- Theoretically, by cutting 1 mg/l chlorine and 1 mg/l sulfite from the dosing, results point to the opportunity to save $15,980 per year on sodium hypochlorite and $12,490 on sodium bisulfite per year, i.e., total $28,470 per year.
Ultra Low Chlorine Performance Test
Ultra-Low Chlorine Validation Test

- Unstable nature of chlorine in water;
- Potassium permanganate (KMnO₄) is adopted as a substitute for the validation test;
- Started with 2.0 mg/l stock solution of KMnO₄, make 1 liter each of various 0.2, 0.02, 0.01 mg/l standard solution via a serial dilution;
- Validate analyzer reading through each standard solution;
- Accuracy: 2 times detection limit or 2% reading whichever greater.
Low Chlorine Validation

Validation Test (May 14, 2015 Waukesha, Wisconsin)

- 0.2 ppm solution run:
  run 1 = 0.217, run 2 = 0.204, run 3 = 0.203; Average = 0.208
  2x LDL = 0.006 ppm x 2 = 0.012 ppm, 2% reading = 0.0042 ppm
  Accuracy range: 0.2 ppm ± 0.012 = 0.188 ~ 0.212 ppm

- 0.02 ppm solution run:
  run 1 = 0.008, run 2 = 0.007, run 3 = 0.008; Average = 0.008 ppm
  2x LDL = 0.006 ppm x 2 = 0.012 ppm, 2% reading = 0.0002 ppm
  Accuracy range: 0.02 ppm ± 0.012 = 0.008 ~ 0.032 ppm.

- 0.01 ppm solution run:
  run 1 = 0.005, run 2 = 0.004, run 3 = 0.005; Average = 0.005 ppm
  2x LDL = 0.005 ppm x 2 = 0.012 ppm, 2% reading = 0.0001 ppm
  Accuracy range: 0.01 ppm ± 0.012 = 0.00 ~ 0.022 ppm.
Ultra Low Chlorine Validation

**Analyzer Validation** (July 22, 2015 Guelph WWTP, Ontario)

- **2.0 ppm solution run:**
  run 1 = 2.006, run 2 = 2.031, run 3 = 2.043; Average = 2.027
  2x LDL = 0.006 ppm x 2 = 0.012 ppm, 2% reading = 0.041 ppm
  Accuracy range: 2.0 ppm ± 0.041 = 1.959 ~ 2.041 ppm

- **0.01 ppm solution run:**
  run 1 = 0.013, run 2 = 0.005, run 3 = 0.003; Average = 0.007 ppm
  2x LDL = 0.005 ppm x 2 = 0.012 ppm, 2% reading = 0.0001 ppm
  Accuracy range: 0.01 ppm ± 0.012 = 0.00 ~ 0.022 ppm.
Conclusion

- A chlorine and sulfite analyzer demonstrated accurate and reliable at ultra-low level measurement.

- The analyzer data and ORP data show some similar trending, but ORP data doesn’t respond to the true chlorine and sulfite variation.

- Co-exist of chlorine and sulfite in wastewater is clearly observed through series of test runs. Therefore, using trace level sulfite only as an indicator of non-exist chlorine may not be the best practice. Residual sulfite needs to be precisely monitored and controlled.

- At the City of Guelph, maintaining a 0.2 – 0.4 mg/l SO3 operational range is suggested to keep total residual chlorine less than 0.02 mg/l range.

- Chemical Saving can be achieved by applying a reliable and accurate chlorine ultra low chlorine and sulfite analyzer.
Thank You!