Evaluating DBP Formation & Distribution System Practices

What's YOUR Water Age?

Presented by: Eric T. Anderson, PE
Outline

- Why we are concerned about DBPs
- Factors affecting DBP Formation
- DBP Reduction Strategies
LT2 and D/ DBP Rule Regulations

- LT2 and Stage 2 DBP Rule
  - Additional disinfection requirements for systems at higher risk based on crypto sampling
  - Average DBPs must be below MCL at every monitoring location

- First full year of compliance monitoring complete in October 2014
Health Effects of DBPs

- Exposure pathways
  - Ingestion
  - Inhalation
  - Dermal

- Potential harmful effects: Carcinogen
  - Bladder, rectal and colon cancer
  - Exposure during pregnancy
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Factors Affecting DBP Formation

Route 522 Tank TTHM (mg/L)

- August TTHM
- Route 522 Tank TTHM (mg/L)
Factors Affecting DBP Formation

General DBP Formation Model

\[ DBPs = a(\text{TOC})^b(\text{UV}_{254})^c(\text{Br+d})^e(\text{pH})^f(\text{Cl}_2 \text{ dose})^g(\text{Time})^h(\text{Temp})^i \]
Factors Affecting DBP Formation

- **TOC/DOC and UV\textsubscript{254}**
  - Broad indicators of natural organic matter levels
  - Different types of natural organic matter produce differing amounts of DBPs
    - Humic Substances
      - More easily removed
    - Non-humics & structurally defined NOM
Factors Affecting DBP Formation

Comparison of THMFP Values

Standard test conditions: 3-Day Reaction Time; pH 7; 20°C

Formation Potentials of NOM Fractions

- FP
  - High dose
  - Forces reaction to endpoint

TOC (mg/L) vs. Std THMFP (µg/L)
Factors Affecting DBP Formation

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Factors Affecting DBP Formation

- **pH**
  - HAAs decrease with increasing pH
  - TTHMs increase with increasing pH
  - No sweet spot to operate in to reduce both
Factors Affecting DBP Formation

\[ DBPs = a(\text{TOC})^b(\text{UV}_{254})^c(\text{Br+d})^e(\text{pH})^f(\text{Cl}_2 \text{ dose})^g(\text{Time})^h(\text{Temp})^i \]
Factors Affecting DBP Formation

- **Time (Water Age)**

![Graph showing Time (Days) vs. TTHM (μg/L) for different locations: Bedford, Front Royal, Philpott, Martinsville, Covington.](image)
Factors Affecting DBP Formation

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Factors Affecting DBP Formation

- Temperature

![Graph showing the relationship between HAA5 and TTHM levels with raw temperature over time.](image)
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DBP Reduction Strategies

- Delay the point of chlorine addition
- Pre-oxidant addition
- Powdered activated carbon addition
- Distribution system flushing
- Source water control
- MIEX pretreatment
- Pre-treatment improvements
- Decrease distribution system storage
- Increase distribution tank cycling
- Add distribution tank mixing and ventilation
- Add tank aeration for TTHM removal
- Granular Activated Carbon (GAC)
- System-wide or specific location chloramination
DBP Reduction Strategies

- Reevaluate the plants disinfection profile
DBP Reduction Strategies

Avoid chlorine addition in raw water
DBP Reduction Strategies

- **Pre-oxidant Addition**
  - Add in well before chlorine addition
  - React with NOM in a way that does not produce regulated or harmful DBPs

*From AWWA Water Quality and Treatment*
DBP Reduction Strategies

Pre-oxidant Addition – Jar Test Evaluation

- Current Practice
- Sodium Permanganate
- Chlorine Dioxide
- Chlorine Dioxide/MIE
- Chlorine Dioxide/GAC

TTHM level (µg/L)

Finished Water
After 25 Day Detention
TTHM MCL
DBP Reduction Strategies

■ Pre-Treatment
  ♦ Examine SUVA values
    • SUVA = Removal potential by pre-treatment
    • Simplified Formula = $\text{UV}_{254}/\text{DOC}$
    • Values above 2.5 indicate coagulation can result in good removal of DBP precursors
  ♦ If SUVA is consistently high, consider dosing coagulant based on $\text{UV}_{254}$ instead of turbidity
DBP Reduction Strategies

- **Tank Aeration**
  - TTHM removal only
  - No other DBP is affected by this treatment
  - Commercial systems are expensive
  - Custom systems yield uncertain results
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