Impact of Nitrogen Removal in Wastewater Treatment on DBP Formation at Downstream Drinking Water Treatment Plants

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The statements in this presentation do not necessarily reflect the view of the EPA.
Watersheds are both Drinking Water Sources and Wastewater Sinks
De Facto Reuse (DFR) occurs when the receiving water for wastewater effluent serves as the source water for a downstream drinking water treatment plant

- National survey of DWTPs (Rice and Westerhoff, 2015) indicated ~50% of intakes were influenced by DFR

- About half of the impacted intakes had DFR greater than 1% by volume

- Nutrients that pass through wastewater treatment have the potential to impact downstream DWTPs.

Treatment occurs at the **drinking water** treatment plant.

- Coagulation/flocculation and sedimentation
- Filtration
- **Disinfection** *Critical*

Add chlorine or chloramine to kill pathogens, bacteria, and other living organisms in the water.

\[ \text{Cl}_2 + \text{Organics} = \text{Disinfection Byproducts (DBPs)} \]

\[ \text{Cl}_2 + \text{Organics} + N = N-\text{DBPs} \]

- DBPs Have been linked to adverse reproductive effects and carcinogenicity
- Nitrogenous species are more toxic than their carbonaceous counterparts
- No \( N \)-DBP regulations!
  - California notification level for NDMA is 10 ppt (ng/L)
Treatment occurs at the waste water treatment plant.

- Primary Settling
- Secondary BOD removal (activated sludge, trickling filter)
- Tertiary Nutrient Removal
  - Nitrification
  - Denitrification
  - Bio P removal
Understanding the potential effects of wastewater treatment on drinking water systems requires data!

- 2008 Clean Watersheds Needs Survey (CWNS)
  - WW discharge volumes
  - Nitrogen treatment

- Second Unregulated Contaminant Monitoring Rule (UCMR2)
  - Distribution system NDMA

\[
\text{N} - \text{N} = 0
\]
Understanding the potential effects of wastewater treatment on drinking water systems requires data!

• Started with a list of previously ground-truthed DWTPs where high de facto reuse (DFR) was present (identified by Rice et al. 2015)
  • DFR estimate based on average streamflow and upstream WWTP discharge volumes
• Further refined the list
  • Single surface water intake plants
  • No potential international contributions
  • Chlorine (16) or chloramine (16) disinfectants

“High DFR set” 31 systems

“UCMR2 set” 318 systems

• Compared with full set of UCMR2 plants that:
  • Served >10,000 people
  • Used chlorine/chloramine
  • Surface water as source

DRINCs model identified the potential de facto reuse locations.

Each wastewater plant was classified by its treatment type: Conventional, Nitrifying, BNR.

Each waste stream entering a DW plant was classified by the fraction of the indirect reuse associated with different nitrogen conversion.

\[
\text{Fraction Nitrified} = \frac{\text{WW flow from plants with ammonia removal}}{\text{Total contributing WW flow}}
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\text{Fraction Denitrified} = \frac{\text{WW flow from plants with nitrogen removal}}{\text{Total contributing WW flow}}
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\text{Fraction N Treatment} = \frac{\text{WW flow from plants with nitrogen or ammonia removal}}{\text{Total contributing WW flow}}
\]
NDMA at high DFR plants had higher detection rates and threshold exceedance than the UCMR2 baseline
Proximity matters as nitrogen is transformed in surface waters through natural processes.

Nitrogen is transformed and lost in the surface water.
The analysis was replicated using different distance cutoffs for each DW plant.

- 50km
- 100km
- 150km
De Facto reuse and upstream treatment affect NDMA formation potential downstream.

Distance had an important impact on this relationship.
Acknowledgements