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



Jeanne M. VanBriesen, Ph.D., P.E.

Duquesne Light Company Professor of Civil and Environmental Engineering and Engineering and Public Policy

Director, Water QUEST (Water Quality in Urban Environmental Systems)

Carnegie Mellon University

Adam Cadwallader, Ph.D.

Oak Ridge Institute for Science and Education (ORISE) Fellow United States Environmental Protection Agency



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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



Rice, J., and Westerhoff, P. (2015). "Spatial and Temporal Variation in De Facto Wastewater Reuse in Drinking Water Systems across the U.S.A." *Environmental Science & Technology*, 49(2), 982-989.

Treatment occurs at the <u>drinking water</u> treatment plant.



- 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 <u>waste water</u> 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

$$N - N = O$$

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 "High DFR set" and systems
- Further refined the list
 - Single surface water intake plants
 - No potential international contributions
 - Chlorine (16) or chloramine (16) disinfectants
- NCMR2 Set" systems Compared with full set of UCMR2 plants that:
 - Served >10,000 people
 - Used chlorine/chloramine
 - Surface water as source



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.

 $Fraction \ Nitrified = \frac{WW \ flow \ from \ plants \ with \ ammonia \ removal}{Total \ contributing \ WW \ flow}$

 $Fraction \ Denitrified = \frac{WW \ flow \ from \ plants \ with \ nitrogen \ removal}{Total \ contributing \ WW \ flow}$

 $Fraction N Treatment = \frac{WW flow from plants with nitrogen or ammonia removal}{Total contributing WW flow}$

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.







50km

100km

150km

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