DE FACTO REUSE IMPACTS ON DRINKING WATER QUALITY AT SMALL PUBLIC WATER SYSTEMS IN THE UNITED STATES

Thuy Nguyen[1] and Paul Westerhoff[1]
[1]*School of Sustainable Engineering and the Built Environment*
Arizona State University, Tempe, Arizona, 85281

I. Background

- Nearly 15,000 WWTPs serve about 76% percent of the U.S. population with approximately 238.2 million people in 2012
- De facto reuse (DFR) occurs when treated wastewater is discharged into the upstream of a public water system (PWS)
- Many of contaminants of emerging concerns (CECs) and pathogens (such as *Cryptosporidium parvum* or *Giardia lamblia)* in treated effluents can resist removal through conventional water treatment processes and enter potable water
- Our prior study concluded that >50% of large PWSs serving > 10,000 people (N = 2,160) have at least one wastewater treatment plant (WWTP) discharge upstream[1]
- However, about three times more PWS surface water intakes serving communities <10,000 people

Research Need

- To perform a complete national wide analysis of extent de facto potable reuse and predict population expose to CECs in tap water

II. Modeling Approach

- A geospatial model of the De Facto Reuse Incidence in our Nations Consumable Supply (DRINCS)
- Expand the DRINCS model with the EPA database for small PWSs (Surface water intakes = 5,184)
- Outfalls of treated wastewater to surface water in the US (N = 14,651) obtained from Clean Watershed Needs Survey 2008
- National Hydrography Dataset (1:100,000 scale) (USGS NHD)
- Validation of the DRINCS with field observation of the CECs occurrence at PWSs[3]
- Equation: $DFR = \frac{\sum Q_{ww,i}}{Q_{SW}} \times 100\%$
  - $Q_{ww,i}$:cumulative upstream WWTP design discharges (cfs)
  - Q_{sw} :streamflow at the surface water intake (cfs)

III. Modeling Results

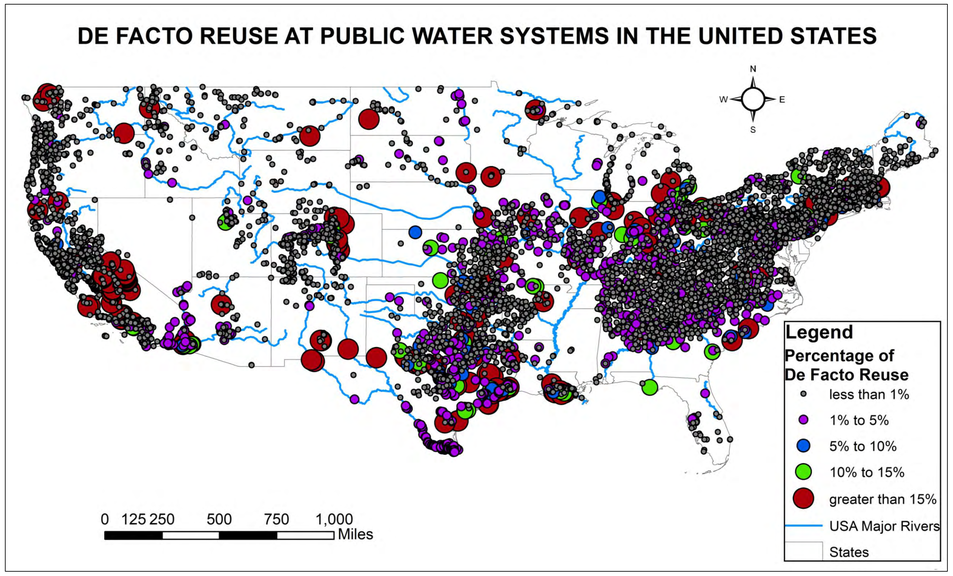

Fig 1. Nationwide de facto reuse at PWSs under mean annual streamflow condition (all surface water intakes were completely groundtruthed for precise locations (N = 8, 969)

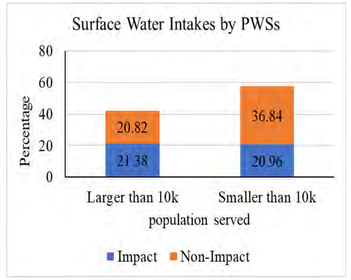

Fig 2. Number of surface water intakes non- or impacted by treated wastewater upstream categorized based upon population served by a public water system

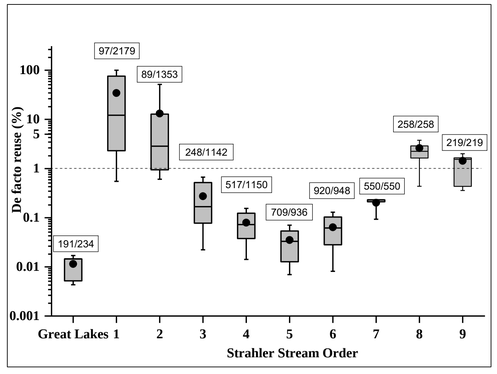

Fig 3. De facto reuse at PWSs as a function of Strahler stream order. Top and bottom of box = 75th and 25th percentiles respectively; top and bottom of whisker = 90th and 10th percentiles respectively; line across inside of box = median (50th percentile). 191/234 = 191 is the number of surface water intakes with DFR>0 upstream WWTPs and 234 is the total PWS surface water intakes)

IV. Conclusions

- More than 40% of surface water intakes by all PWSs in the U.S were impacted by treated wastewater upstream under mean annual streamflow condition (N = 3,798)
- High occurrence of DFR at smaller PWSs under mean annual streamflow with about 50% surface water intakes impacted by treated wastewater (N = 1,880)
- Smallest streams (1st order and 2nd order) or largest streams had higher DFR
- PWS intakes on the 3rd through 7th order stream had DFR below 1% due to natural runoff diluting wastewater

V. Future Work

- Further statistical analysis on DFR levels at large PWSs and smaller system (serving more or less than 10,000 people)
- Modernize the DRINCS 2.0 model with year 2012 WWTP information
- Groundtruth work for all outfalls of treated wastewater to surface water (N ~ 15,000)

Application of the DRINCS

- The DRINCS model is capable of estimating travel times which are important to understand the natural attenuation capacity of surface water systems for wastewater-derived CECs
- Identify hotspots (with higher risk of) de facto potable reuse where monitoring programs could be performed and where infrastructure upgrades could most effectively reduce human exposures to CECs.

References and Acknowledgement

1. Rice, J., Via, S. H., & Westerhoff, P. (2015). Extent and Impacts of Unplanned Wastewater Reuse in US Rivers. *Journal: American Water Works Association*, *107*(11).
2. Nguyen, T., Westerhoff, P. (2019). Drinking water vulnerability in less-populated communities in Texas to wastewater-derived contaminants. *npj Clean Water 2, no. 1* (2019): 1-9.
3. Nguyen, T., Westerhoff, P., Furlong, E.T., Kolpin, D.W., Batt, A.L., Mash, H.E., Schenck, K.M., Boone, J.S., Rice, J. & Glassmeyer, S.T. (2018). Modeled de facto reuse and contaminants of emerging concern in drinking water source waters. *Journal-American Water Works Association, 110*(4).

Acknowledgement

The authors would like to thank Vietnam Education Foundation (VEF), Decision Center for a Desert City (DCDC) and ASU's Future H2O that funded this research. We would like to thank **Julianna Acero** for her assistance in ground-truthing facility locations