Thesis Portfolio

Characterizing the Prevalence and Mitigating Possible Risks of Wastewater Borne Antibiotic Resistance
(Technical Report)

Analysis of Risk Communication regarding PFAS Contamination in Cottage Grove, MN
(STS Research Paper)

An Undergraduate Thesis
Presented to

The Faculty of the
School of Engineering and Applied Science
University of Virginia

In Partial Fulfillment
Of the Requirements for the Degree
Bachelor of Science in Civil Engineering

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May 2, 2020

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Emerging contaminants are pollutants measured in the water supply that have ill-defined health impacts and few or no regulations. As scientists begin to research and understand the health impacts of an emerging contaminant, the pollutant may already be in the environment and therefore pose a health risk to a community. Emerging contaminants may be biological pollutants or chemical pollutants and enter the water supply through point or non-point sources. There are a number of challenges that decision makers face when managing emerging contaminants. These challenges include defining the extent and transport of the contaminant, creating appropriate regulations, evaluating potential interventions and treatments, and responsible risk communication with the public throughout the process. This research explores a couple of these challenges by looking at two emerging contaminants: hospital-borne antibiotic resistant bacteria (ARB), a biological pollutant, and polyfluoroalkyl substances (PFAS), an industrial pollutant.

Antibiotic-resistant bacteria (ARB) are a growing public health concern (CDC, 2019a). In the U.S. alone, 2 million people contract antibiotic-resistant infections annually with approximately 23,000 fatal infections (CDC, 2019a). A relatively new species of ARB, *Klebsiella pneumoniae* carbapenemase (KPC), has impacted patient health at the University of Virginia (UVA) hospital system. KPC-positive ARBs from infected patients in the UVA hospital have been shown to colonize hospital sinks and toilets, leading to an increased risk of hospital-borne infections. The presence of ARB in the plumbing of the hospital also raises concerns about the transfer of ARB to the local wastewater treatment plant (WWTP) via hospital sewage and eventually into the environment, but the extent of this transfer and is unknown. Identifying and evaluating effective intervention methods is an additional concern of stakeholders. This research was conducted in two parts. Part I characterized the transport of ARBs in the wastewater treatment system, using KPC-positive bacteria as a model. We conducted quantitative and enrichment

analyses on samples collected from throughout the system. Culture analyses revealed KPC-positive bacteria present in the hospital plumbing, wastewater influent, secondary sludge, digester influent and effluent, and the downstream water of Moores Creek. KPC-positive bacteria were not found in the WWTP final effluent, the upstream water, or the upstream and downstream sediment. Part II of the study focused on how to evaluate possible interventions that could be used to protect human and ecosystem health from possible health risk associated with exposure to KPC-positive ARB. The research conducted in Part I and a literature review provided the background for the intervention design criteria. We scored eight interventions that covered multiple parts of the system including point-of-use at the hospital sinks, on-site treatment at the hospital, and municipal solutions at the WWTP. Using nine criteria we identified physical coverings for hoppers, antimicrobial surfaces, on-site wastewater treatment, and chlorination and UV disinfection as viable candidates for further investigation.

Effective and clear risk communication is essential to create awareness and understanding of a risk so that individuals and communities can make decisions that protect public health. A type of emerging contaminant known as “forever chemicals” or per and polyfluoroalkyl substances (PFAS) has been a cause of great concern in towns across the United States. One such town, Cottage Grove, Minnesota, has PFAS contamination due to former industrial activities. In 2017, health advisories dictating acceptable PFAS levels in drinking water were lowered, requiring the local government to communicate these changes and potential risks. I evaluated the efficacy of risk communication in Cottage Grove, MN using a World Health Organization (WHO) framework. My analysis revealed that the city and state government successfully addressed many components of risk communication including interacting with a lay audience, a responsive process, monitoring of the PFAS levels, and effective leverage of social media outlets. I also identified areas for

improvement including the active engagement of the public earlier in the risk identification process.

My team's research on hospital-borne ARBs successfully contributed to the understanding of how KPC-positive bacteria is transported through the wastewater treatment process. We identified bacteria downstream of the wastewater treatment plant that was almost genetically identical to bacteria recovered from patients in UVA hospital. KPC-positive bacteria are not found in the WWTP effluent itself, however, grab samples provide a snapshot of water quality. Further long-term research needs to be conducted to determine if KPC-positive bacteria could be in the final effluent. The research also provided preliminary analysis of potential interventions. A more robust process will be required to make a recommendation to the city of Charlottesville and UVA hospital. The research on Cottage Grove provided insight into how the local government handled risk communication in response to new PFAS regulations. This study covered a short period of time and further research could explore risk communication in a different or extended timeframe. Another opportunity would be to conduct stakeholder and participant interviews to measure effectiveness of risk communication in lieu of the WHO framework.