Mitigating Wastewater-borne Antibiotic Resistance at Point-of-Use and WWTP Scales

(Technical Paper)

Evaluating PFAS Risk Communication Methods in Minnesota

(STS Paper)

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General Research Problem

How can stakeholders better manage emerging contaminants to reduce harm to individuals and communities?

Modern society and industrialization have increased the number of human-manufactured risks (Giddens et. al. 2017). Emerging contaminants are one type of these risks. Emerging contaminants are pollutants measured in the water supply that have ill-defined health impacts and few or no regulations (WQA 2019). Antibiotic resistant bacteria (ARB) and per- and polyfluoroalkyl substances (PFAS) are both examples of emerging contaminants (Cordner et al. 2019; Mathers et al. 2019). Although pathogenic bacteria are naturally occurring, the increase in ARBs or "superbugs" is exacerbated by the misuse of antibiotics in humans and animals (CDC 2019). Research on the transport of ARBs in sewage systems and the potential health impact are still being explored. PFAS, on the other hand, are industrial chemicals that have impaired drinking water systems across the United States, and safe levels of consumption are still being defined. Continued research is imperative to develop more effective treatment methods and communicate risk to impacted communities responsibly.

Mitigating Wastewater-borne Antibiotic Resistance at Point-of-Use and Wastewater Treatment Plant (WWTP) Scales

What is the most effective method for eliminating ARB bacteria at the point-of-use and WWTP scale?

Antibiotic resistant bacteria (ARB) are a growing public health concern (CDC 2019). In the U.S. alone 2 million people contract antibiotic-resistance infections annually with approximately 23,000 fatal infections (CDC, 2019). A relatively new species of ARB, Klebsiella pneumoniae carbapenemase (KPC), has impacted patient health at the University of Virginia Health System University Hospital. KPC infected patients have seeded sinks in UVA hospital which has led other patients to develop hospital borne infections from drain-to-patient interactions (Mathers et al. 2019). The lack of effective sanitation methods in this context puts future immunocompromised patients also at risk.

ARB from the hospital are also believed to be spread in sewage. Sewage from the UVA Hospital is treated at the Rivanna Water and Sewer Authority Wastewater Treatment Plant (WWTP). The treated effluent from the WWTP is discharged into the nearby Moore's Creek. Initial sampling performed this summer by Dr. Lisa Colosi Peterson and PhD candidate Erika Loudermilk showed ARB present downstream of the WWTP. Sludge from the wastewater treatment process is sent to McGill Environmental Systems to be composted.

Our research will be completed in two phases. In phase I we will investigate the transport of ARBs containing the KPC gene through the wastewater treatment process and their fate when they enter the environment. We will collect samples from the hospital sewage, WWTP, and Moore's Creek. These samples will be analyzed by real-time polymerase chain reaction (qPCR) and culture methods to test for the presence of the bacteria with the KPC gene.

In Phase II we will test the effectiveness of traditional wastewater treatments such as UV, ozone, and chlorination at eliminating ARBs. First, we will perform benchtop experiments to simulate treatments in a WWTP setting. After determining the most effective treatment method, we will begin prototyping a point-of use design that could be applied to a hospital sink. Prototypes will be tested at UVA's sink lab, an academic lab overseen by Dr. Amy Mathers and Dr. Shireen Kotay, in the UVA School of Medicine, where researchers study the spread of infectious diseases via hospital sinks (UVA School of Medicine, 2019). This lab will allow us to simulate hospital conditions as our prototype must be able to be applied to an already existing system.

At the end of this study, our team will identify the most effective treatment method for ARBs at a WWTP scale. This knowledge will not only be useful to the Charlottesville community but other cities impacted by a growing concern over ARBs in the water system. Ideally, our team will also have developed a working prototype that effectively sanitizes the drains of hospital sinks. This project has the potential to improve the health of patients at UVA hospital and downstream of the WWTP.

Evaluating PFAS Risk Communication Methods in Minnesota

Was the risk of PFAS contamination in Minnesota responsibly and effectively communicated to community members?

Introduction

Per and polyfluoroalkyl substances (PFAS) are a group of human-made chemicals manufactured in U.S. since the 1950s (U.S. EPA, 2019). PFAS are stable chemicals that effectively repel both water and oil (RI Department of Health, 2019). Because of these key properties, PFAS are used in a variety of products, including nonstick pans, stain repellants, and firefighting foam (Kary 2018, Snider 2018, Van Rossum 2017). The chemicals' stability, however, means that they do not easily break down and that they persist in the environment. PFAS chemicals now pollute drinking water sources in towns across the United States (Marohn 2019). Detectable levels have even been found in human and animal blood (Marohn 2019). Continued PFAS exposure can lead to increased risk of cancer, thyroid disease, and high cholesterol levels as well as infertility and developmental defects in infants (Health, 2019). Although the two most common types of PFAS (perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)) were voluntarily phased out of 3M production in 2000 (3M, 2019), historical contamination still exists today as well as other PFAS chemicals still used in manufacturing (U.S. EPA 2019). As research regarding PFAS toxicity continues, policies change and develop (Cordner et al., 2019; Kary 2019). The EPA has issued a nonbinding federal Health Advisory (HA) of 70 ng/L (U.S. EPA 2019). This recommended level is lower than the original HA as exposure research and advances in technology have allowed for more accurate PFAS measurements (Cordner et al., 2019). With continually evolving policies and scientific understanding communication of the associated risks can be challenging. How does a government agency, environmental organization, or corporation provide transparency and information when the problem is not fully defined? Are the best practices in risk communication being followed for communities impacted by PFAS contamination and how could they be improved? In this research I will investigate how the public is currently informed about PFAS in Minnesota, how it compares to risk communication standards, and opportunities for improvement.

Background and Theoretical Framework

The original PFAS production began at a 3M plant in Cottage Grove, MN in 1950s. Producing and improperly disposing of these chemicals for decades contaminated much of the East Metro Area of the Twin Cities (Brown 2019). There are five main sources of the contaminates in the area: the 3M Cottage Grove Facility, the 3M Woodbury Disposal Site, the Washington County Landfill, the 3M Oakdale Disposal Site, and Pigs Eye Dump. These point sources polluted much of the groundwater including four major aquifers, eight municipal systems, and approximately 2,000 private wells (Kary 2018).

In 2002, Cottage Grove residents learned about unsafe levels of PFAS in drinking water when the Minnesota Department of Health issued new, stricter regulations for PFAS concentrations (Kary & Cannon 2018; Krueger 2018). Although the extent of PFAS contamination in the area is now known, there was a period of time where the risk had been identified but little was understood about the potential for harm.

As PFAS research and PFAS remediation projects developed, litigation against manufacturing companies also began. In 2018, the State of Minnesota reached an $850 million settlement with 3M. $125 million compensated the state for legal counsel and $4.5 million reimbursed the state for previous cleanup costs (Krueger, 2018). The remaining money ($720 million) will pay for long term solutions that address clean drinking water and restoring natural resources in the East Metro Area (Krueger, 2018).

Understanding how to effectively communicate risk is imperative to the successful management of environmental problems. Whereas a hazard is related to the actual damage that could occur due to an environmental issue, risk describes the public perception of the problem (Giddens et. al. 2017). A sense of risk can be powerful both to reduce or exacerbate further harm. Amplifying risk can create awareness and ultimately action. This can reduce the amount of further harm or risk. Risk communication, however, can also lead to a sense of powerlessness, which may be detrimental to communities (Kasperson, 2012). Because of the potential of these repercussions multiple guidelines for communicating environmental and health risk have been developed.

One of the best ways of measuring efficacy of risk communication is to review the subsequent actions taken by the community and study the current perception of the risk. Although I will investigate remediation actions, legislation, and litigation regarding PFAS contamination I will not be conducting interviews to gauge perception. To fill this gap, I will be evaluating risk communication documents using the World Health Organization environmental and public health risk communication framework. This widely used framework will provide guidance as to how to evaluate the risk communication.

Data Collection and Methods

A network of individuals and organizations were responsible for informing the public as the understanding of PFAS contamination developed. This network includes the local government, potentially responsible parties such as the 3M Corporation, scientists, community organizations, and the media. To understand how PFAS risk has been communicated, I will perform a content analysis of information provided to the public about PFAS. I will analyze minutes from relevant policy documents, reports from scientists, informational pamphlets, and town hall meeting minutes. I will also analyze media outlets including the Star Tribune and Pioneer Press, two newspapers in high circulation. The media is used to inform the public, express the opinions of individuals or groups in op-eds, and advertise public meetings making it an especially useful source. Recordings of public discussions are also available through the local government websites, which I will transcribe and perform content analysis on as well.

These documents will help me determine how risks were communicated in the wake of PFAS contamination of drinking water in Minnesota. During analysis I will identify relevant and repeated themes. By the end of this research I will have identified the strengths and weaknesses of PFAS risk communication based on how the communication aligns with the WHO standards and form recommendations for how this can improve in the future. These findings can be used to in Minnesota and may potentially benefit other communities facing similar PFAS contamination challenges.

Conclusion

Emerging contaminants continue to threaten and impact environmental and human health. Because of this, continued research is essential to reduce the potential for harm to the public and individuals. Study dedicated to characterizing the transport of ARB in the sewage system and the most effective treatment methods will promote the health of the Charlottesville community and beyond. An analysis of risk communication regarding PFAS contamination will identify strengths and weaknesses of the process. These findings can be used to improve the ongoing efforts to protect communities from harm through technical fixes and improved communication.

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