

Undergraduate Thesis Prospectus

**Characterizing the Prevalence and Mitigating Possible
Risks of Wastewater Borne Antibiotic Resistance**

(technical research project in Civil Engineering)

**Sanitation and Sanitary Products:
Threats to Wastewater Systems**

(STS research project)

by

Dorian Nguyen

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technical project collaborators:

Meredith Sutton

Anna Cerf

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

signed: _____ date: _____

approved: _____ date: _____
Peter Norton, Department of Engineering and Society

approved: _____ date: _____
Lisa Colosi Peterson, Department of Engineering Systems and the
Environment

General Research Problem: Contamination in Public Wastewater Systems

How are public wastewater systems adapting to contamination?

Wastewater systems have been slowly inundated with foreign materials such as “flushable” wet wipes and pharmaceuticals. Municipal residents see toilets as an instant disposal method for bathroom products; however, the sanitary products do not disintegrate like waste and toilet paper (the only items meant for wastewater systems) and pharmaceuticals are unable to be processed through traditional treatment methods, leaching into local waterways. Sanitary products accumulate to large clusters that can block the system and clog pumps (Mitchell & Thamsen, 2017). Repairs on wastewater systems are costly; also, issues left unchecked create public health hazards by exposing local wildlife to hormones and other chemicals. Wastewater treatment plants need to update their infrastructure to better handle the changing landscape of wastewater; however, we must be more mindful of how we view and dispose of our waste.

Mitigation of Antibiotic-Resistant Bacteria in UVA Hospital Wastewater

How can we mitigate wastewater-borne antibiotic resistance at the UVA Hospital?

The technical advisor is Lisa Colosi Peterson of the Engineering Systems and the Environment Department, and I am working with Meredith Sutton and Anna Cerf on this team capstone. The goal of this project is to evaluate wastewater treatment techniques (ozonation, UV, chlorination, etc) to develop point-of-use methods to prevent the spread and creation of Antibiotic-Resistant Bacteria (ARB) within the UVA hospital. We are specifically looking at Carbapenem-resistant bacteria, as carbapenems are important antibiotics because they are the drug of last resort for bacterial infections.

When consumed, antibiotics do not fully process within the body. Some get excreted with fecal matter and enters the bathroom environment and wastewater when flushed. Fecal matter coat bathroom surfaces and gut/fecal bacteria become inoculated to antibiotics within the fecal matter creating ARB's. Despite thorough cleaning, biofilms develop under sink drains and toilets and provide optimal growth mediums for bacteria. Because of this, hospital bathrooms are one of the most common sites of antibiotic-resistant hospital-acquired bacterial infections (Buchan et al., 2019).

ARB's are currently managed by prescribing a variety of antibiotics to treat infections with the assumption that at least one of the antibiotics will treat and manage the infection. However, this does more harm than good by letting bacteria develop resistance to new antibiotics if they are not fully managed (NYU Langone Health, n.d.). Carbapenem-resistant bacterial infections are especially unique as they have very limited treatment options and high mortality rates (Gupta et al., 2011). In a study of seven patients with liver transplants that became infected with Carbapenem-resistant bacteria, six died as there were no effective treatment options (Mathers et al, 2009).

Because of the danger and magnitude of Carbapenem-resistant bacteria, current research is focused on preventing infections and minimizing the spread rather than treatment. There is sizable research on point of use solutions and their effectiveness within hospitals themselves; therefore, a large portion of this project is dedicated to understanding how ARB's are managed (if at all) within wastewater treatment and the downstream environment as there is little knowledge on the topic. If they are not being managed, we will be looking into ways to improve current techniques and equipment.

One experimental point of use solution was to eliminate all sinks within hospital rooms, which greatly reduced the colonization of bacteria within the room; however, no data was collected on infection rates and there is still discussion on the benefits of sinks within hospital rooms (Hopman et al., 2017).

To ensure that our research is relevant, we will sample sites upstream and downstream the wastewater treatment plant (WWTP), within the WWTP, and at the hospital itself to ensure the only source of KPC is from the hospital and if the current wastewater treatment methods are sufficient. We will be working with UVA Pathology Department to grow the samples using quantitative polymerase chain reaction (qPCR) and culture methods to look for microorganisms that are resistant to Carbapenems. If everything goes to plan, we will also work within the UVA Sink Lab to develop an understanding of how to experiment with the equipment.

Next semester, after characterizing the spread of ARB within UVA Hospital, we will be prototyping point-of-use solutions for hospital bathrooms to eliminate ARB without the use of antibiotics and, if needed, we will also develop benchtop wastewater treatment solutions.

By the end of a successful project, our group should have characterized the spread of Carbapenem-resistant bacteria throughout the UVA Hospital and possibly the local environment as well. We would also develop a prototype of a device to minimize bacteria growth, and thus infections, within hospital bathrooms. We hope to see this project be taken on a larger scale to improve other hospitals dealing with outbreaks of Carbapenem-resistant bacteria.

Sanitation and Sanitary Products: Influences that Promote Healthy Public

Infrastructure

How are Municipal Water Authorities, Residents, and Sanitary Product Manufacturers Striving to Influence Flushing Behavior?

Effective wastewater systems are essential in any modern society. They remove harmful and diseased wastewater from our homes and communities and treat it to be able to return it to the local environment safely (USGS, n.d.). However, this can only be true if the systems are running and managed properly. Most systems are capable of handling only two types of material: human waste and toilet paper as they disintegrate easily in water. In recent years, “flushable wipes” have flooded the market claiming that they clean better than toilet paper while still being flushable; however, “flushable” does not mean disintegratable. In sewer systems, wipes and other improperly flushed products accumulate into large clusters and create blockages that require costly repairs (Mitchell & Thamsen, 2017). New York City has spent over 18 million dollars from 2010-2015 clearing out wipe related issues such as clogged pumps and backed up pipes (Flegenheimer, 2015). Water authorities have pleaded with residents to only flush what the system is capable of handling; however, the emergence of third-party participants proclaiming their products as flushable and residents’ desire to feel clean and independent with their actions have complicated the dynamic between the authorities and community residents.

There is a plethora of research and articles about the danger of clogged sewers and pumps due to flushed items as it is unanimous among experts and researchers that only human waste and toilet paper go down the toilet (Seattle.gov, n.d.). However,

information has yet to be effectively spread to residents and communities. For example, flushing tampons has been a much longer-standing problem; albeit, on a lesser scale than wet wipes. In an unofficial survey of over 10,000 people, 50% of participants did not know they could not flush tampons and 20% said they knew but chose to flush anyways (Bielanko, 2017). Although the data is probably skewed; the results are concerning. The widespread ignorance of proper flushing behavior can be remediated through educational efforts; the general public is generally receptive to corrective actions that support the environment (Thiengkamol, 2012). However, the issue is more complex and personal than general environmentalism due to the personal nature of bathroom use and the additional 3rd party manufacturers.

Universally, water authorities act in what they think is in the best interest of their constituents, which is producing cheap clean water. They look to minimize costs and to maximize output to ensure quality water production (Rivanna Authorities, n.d.). They strive to keep contaminants, such as wet wipes and tampons, out of their systems; however, many treatment plants utilize older and dated equipment unable to process most contaminants (Seattle.gov, n.d.).

Residents who flush emerging contaminants, such as wet wipes and tampons, into municipal wastewater presumably value convenience more than what is best for the community. There are usually other vectors for disposal, such as trash (which ends up in the landfill); however, toilet disposal is instant and residents do not worry about what happens afterwards (Kotex, n.d.).

Wet wipes manufacturers who label their products as “flushable”, such as Cottonelle, argue that their products are harmless to sewer systems (Cottonelle, n.d.). By

doing so, they market a product that is more effective than regular toilet paper while still maintaining the same disposal mechanism. However, the definition of “flushability” is contentious between wastewater authorities and manufacturers as many wipes do not disintegrate within sewers: they collect together and amalgamate into blockages (Mitchell & Thamsen, 2017).

Sanitary product manufacturers consistently label their products as non-flushable: Kotex even states on their website to wrap up used tampons and place them into the trash bin (Kotex, n.d.). However, many online blogs and forums, even Kotex’s, have posts stating that individuals just found out that tampons are not flushable after X years of using them. Although they properly label and inform their consumers, it can be said that they are doing the minimum to educate communities.

The National Association of Clean Water Agencies (NACWA) informs the public about the dangers of dumping foreign goods into drains and toilets and promotes legislation to ensure proper labeling of wet wipes as non flushable (NACWA, n.d.). They strive to ensure clean water within local communities and to inform them of their right to clean water (NACWA, n.d.).

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