The Use of Germicidal Light for the Sterilization of the U-bend of Hospital Sinks

(Technical Paper)

The Use of Microbes as a Method to Control Plastic

(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

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Spring, 2020

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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

Introduction

Petroleum based plastics, a versatile invention that is ubiquitous in modern day life, has made thousands of products cheap and easy to produce. However, with this revolutionary material comes a rapidly increasing pollution problem. According to Quinn (2013), the first plastic to be mass produced was Bakelite discovered in 1909, and mass produced in 1929. Since then, plastics have quickly seen rapid integration into variety of products and technologies. The adoption of plastics in numerous products, coupled with the improper disposal process for these plastics, has led to a buildup of petroleum-based products in the ocean. Plastics are notoriously difficult to break down and accumulate in organisms through a biomagnification process, similar to the accumulation of heavy metals. This accumulation of plastic has led to a persistent problem that would take an extremely long time to resolve even if production of petroleum-based products stopped immediately.

Due to the nature of the artificial compounds, there are few natural processes in place that can breakdown artificial polymers. This lack of natural decomposition has led to scientists to look for ways to clean up the products. One source of inspiration to treat this issue is bacteria. Bacteria are some of the most basic organisms on the planet and have shown the ability to survive in extremely hostile environments. Studies have shown that some bacteria possess the ability to breakdown oil spills (Antai 1990), and scientists are working on genetically engineering bacteria to efficiently break down plastics.

For the technical project my research group is working reducing the incidence of hospital acquired infections. Hospital acquired infections are a pressing concern in the modern hospital as 1 in 31 patients end up having a hospital acquired infection. (CDC 2018) These infections lengthen hospital stays and are potentially lethal. We aim to better understand the methods of transmission for these bacteria, and to reduce the number of infections per year.

Technical Topic

Hospital acquired infections are a pressing concern in modern day hospitals, according to the CDC (2018), “there were an estimated 687,000 HAIs in U.S. acute care hospitals in 2015. About 72,000 hospital patients with HAIs died during their hospitalizations.” While this problem is slowly improving over time, it is still a continuous issue fought through policy and technological improvements. My capstone group, (Rex Focht, Bezawit Bogale and Arushi Kumar), has researched what hospital acquired infections are, how they spread, and how they affect patients. We are currently looking into ways to reduce these infections in the hospital environment and are still conducting research on the best way to go about reducing this problem.

The area that my group is focusing on is bacterial infections. Bacteria play a major role in hospital acquired infections and an ongoing goal for hospitals is to prevent their growth and spread throughout the hospital. There are several main types of bacteria that can cause hospital acquired infections including *Clostridium Difficile*, *Staphylococcus Aureus, Klebsiella Pneumonia,* and *Escherichia Coli*. These bacteria can cause a variety of symptoms and infections, most notably bloodstream infections, pneumonia, urinary tract infections, and infections of the large intestine. These bacteria infect patients in a variety of ways. *C. difficile* infects patients by entering an endospore state which is an extremely durable, dormant state of the bacteria, these spores resided in fecal matter and can infect patients when allowed to remain on one’s hands from improper handwashing (CDC 2015). *E. Coli and S. Aureus* are able to infect patients through surgical wounds, catheters, and other open wound sources (CDC 2017). *Klebsiella*, in addition to infections of the bloodstream, is a prevalent cause of pneumonia in patients that need to use ventilators (CDC 2015). All of these infections lengthen recovery times and are potentially lethal to those with weakened immune systems. Our group aims to develop a device that helps limit the number of patients that are infected yearly.

The potential sources of infection that we have looked at researching more about are wastewater transmission, mechanical respirators, and surgical instruments. Wastewater transmission is a major concern with several bacteria which reside in human waste, especially *Clostridium Difficulties*. Bacteria that pass from patients end up growing in the plumbing and can potentially spread to u-bends. When water splashes from a u-bend of a sink or toilet it can act as a carrier for pathogenic bacteria that deposit bacteria in sinks and can potentially infect patients. Mechanical respirators and surgical instruments also serve as vectors for infection.

We plan to focus on a mechanical solution as a method to reduce these infection vectors. The primary area that we are looking into is the sterilization of sinks and other water sources at the moment. Infection from wastewater is a pressing concern where sinks and areas meant to be a method of maintaining a sanitary environment end up being a source of infection. The technical product group seeks to help reduce this problem; however, we are still working on designing a final product. Our prototype plan will be complete by the beginning of December, and the construction of the final product will finish in the spring semester, 2020.

STS Topic

Pollution and global climate change have been a major concern for years; however, a more recent development is the realization of the harm that plastics are having on the ocean ecosystem. This problem is pervasive and persistent. Petroleum based plastics are one of the defining inventions of the twentieth century and have led to the mass production of a variety of products. Plastics are an excellent material because they are versatile, relatively cheap to produce, very slow to decompose and one can produce massive amounts in a relatively short period of time. This availability has led to plastics becoming a massive success as a building material, used worldwide, and seen as ubiquitous in modern day society. However, this success comes at a cost; the properties that make plastics such a good material has led to the existence of a common material used extensively that does not break down through normal biological process.

Currently, plastics permeate the ecosystem; leaving waste, estimated to take decades to centuries to break down, from discarded products free to work their way into the ocean. Plastic straws can take 200 years to decompose naturally, plastic water bottles take approximately 450 years, and fishing line can take up to 600 years to decompose.(Mills 2018) This slow decomposition process would not be a pressing concern if discarded plastic products were stored properly where they could be isolated and allowed to break down without infiltrating water systems and ecosystems, however, due to improper disposal procedures, a number of plastics find their way into the ocean. A study in 2015 estimates that 275 million tons of plastics products find their way into the ocean per year (Jambeck 2017). The growing concern with plastics has led to the development of new technologies to help alleviate the pollution problem, including the use of bacteria as a means of metabolizing these compounds.

The stakeholders for ocean pollution are numerous, and the impact of pollution is far-reaching. Ocean-based ecosystems are also stakeholders in ocean pollution. Petroleum and the plastics derived from petroleum can directly harm the organisms by covering wildlife, catching wildlife in ghost nets, and causing harm when inadvertently consumed by sea life. (Wilcox 2018) When plastics decompose into smaller parts, they can also serve as a pollutant for food sources, through biomagnification these plastics can build up in the food chain, this results in higher concentrations in predators and filter feeders. (Diepens 2018). These plastics occupy space in the organism's stomach, can damage the digestive system, and are potentially lethal. (Wilcox 2018) Finally, plastics subunits can also act as endocrine disrupter in the human body leading to chemical imbalances and a host of detrimental effects to humans. (National Institute for Health 2019) This interest extends beyond individuals affected by this pollution as well; it is vital importance to industries and people that depend on the ocean as a source of food and economic prosperity. Fish stocks already depleted from overfishing can become toxic to humans and put at further risk through the ingestion of plastic. Finally, it makes sense from a tourism standpoint to reduce the amount of plastic in the ocean; pollutants littered onto beaches are both unsightly and can cause hazards to human health. These concerns have led to scientists developing methods of selective bacteria to breakdown plastics.

There are several theories that apply to the use of bacteria as a technology for decomposing plastic waste in the ocean. The first major STS theory address this topic is technological determinism. The determinism theory postulates that the ability of scientist to genetically engineer organisms and the existing processes of using altered bacteria as methods of producing essential medicines such as insulin, could only lead to the implementation of this ability to break down undesired waste from human activities. I believe that the technological momentum framework fits this system best, as this solution pulls from several different fields to be effective, and both this problem and potential solution require technologies for other areas.

The issue of petroleum-based pollution vitally important to the health of the ocean ecosystems. Plastic pollutants have detrimental effects on the organisms and can cause widespread harm to ecosystems. Additionally, plastics can have harmful effects when digested by humans, and the loss of aquatic life as a potential food source harms both people and the industries that relay on these organisms.

Research Question and Methods

The STS research question is how the use of petroleum and plastic has led to the use of plastic digesting microbes as a means to clean up pollution. I plan to approach the problem with two major methods, wicked problem framing and historical case study. The wicked problem-solving method would be optimal for this research question because it encompasses the technological fix and how planning efforts fail. Any time one introduces a new organism into an ecosystem it can heave unforeseen consequences and can affect other organisms in surprising ways. I would also like to use the historical case study method because oil spills have occurred a number of times in the last few decades and bacteria have demonstrated the ability to potentially break down petroleum. Additionally, I could examine the shortcomings of the other methods and better explain why the use of bacteria is a viable option. I plan to organize my research into historical examples and the effects that these examples have had on the environment.

Conclusions

My group technical topic looks at the prevalence of hospital acquired infections and methods of preventing them. The group aims to help reduce the number of infections per year through the alteration or creation of a device to prevent growth and reduce the spread of pathogenic bacteria. This project will focus on limiting the growth of the bacteria and by helping eliminate the vectors they spread through. This topic, though more health oriented than the STS project primarily focuses on the bacteria that harmful to humans and that medical professionals and biomedical engineers are aiming to prevent the growth of.

The STS portion of the project again looks at bacteria, but this time looks into ways that scientist aim to harness them to metabolize petroleum-based products. This project focuses on plastics as an ocean pollutant and how genetic engineering can utilize bacteria's survivability and the ability to thrive in a variety of hostile environments.

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