Thesis Portfolio

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

(Technical Report)

The Use of Microbes to Control Petroleum-Based Plastic Pollution

(STS Research Paper)

An Undergraduate Thesis

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

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

Alexander Knoop
Spring, 2020

Department of Materials Science and Engineering

Table of Contents

Sociotechnical Synthesis

Introduction

My fourth year Capstone project and the STS research paper contains topics that are loosely linked by bacteria. While the Capstone project consists of the study of how to limit bacterial infections in hospitals, the STS research examines the potential of bacteria as a method to reduce ocean plastic pollution. These topics are related because both focus on the role of bacteria in a modern environment, and both examine the potential impact that bacteria can have in their respective environments. In a healthcare setting the hospital environment can affect the amount of Hospital Acquired Infections (HAIs) while in a more natural environment bacteria shape the type of flora and fauna that are able to survive.

Summary of Capstone Project

For the technical project, my research group is working on 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. Our overall aim is to reduce the number of infections per year. From this goal, our project has determined that the growth of bacteria in plumbing, specifically those located in hospital sinks are of particular interest. We aim to improve this situation through designing a device with the intent of eliminating bacterial growth in the p-trap of sinks. Pipe climbing bacteria is a significant problem in hospitals. Often infectious diseases that are washed down sinks or flushed from toilets find a home in the hospital plumbing. Additionally, these bacteria are regularly exposed to low levels of antibiotics which pass through humans undigested. This constant low-level antibiotic exposure allows for bacteria to build up an antibiotic resistance. The presence of infectious bacteria in sinks and bathrooms

can turn sinks intended for sterilization into a vector for bacterial infections for vulnerable patients. Our device kills bacteria that grows in the p-trap (U-bend) through the utilization of germicidal UV-C light. In order to ensure that the germicidal UV light is transmitted into the U-bend of the sink we plan to install a piece of quartz glass to act as a window to for the radiation. Quartz glass was chosen because it is able to transmit UV light while normal glass effectively blocks the transmission. This structure will be contained in a box around the U-bend and light in order to prevent eye damage from the UV light. We believe that this device will help significantly reduce sinks as an infection vector.

Summary of STS Research Paper

Plastics are an essential part of many products used in day to day life, they are prized for their inexpensive production and resistance to natural degradation, however, these factors that make plastics so useful have also led to a build-up of plastic pollution in the ocean. Bacteria are a potential method for cleaning up plastic waste through metabolizing the structure of plastics and subunits produced upon their breakdown. The STS research question addressed in this paper is how the improper disposal of petroleum and plastic has led to the use of plastic digesting microbes as a means to clean up pollution. The method implemented for the STS research in this paper is the historical case study method; this method is optimal for this situation because there is a history of bacteria use to clean up oil spills and historical evidence of the effects of introducing new organisms into an ecosystem. This research follows the Wicked Problem-Solving framework which uses the ideas of the Technical Fix theory to show how planning efforts fail. This paper first examines historical instances of the use of bacteria to metabolize spills and establishes the potential for the bacteria's use as a cleanup method. The STS research

paper then examines the potential issues associated with the implementation of a new organism into an ecosystem and the potential harm that it can cause.

Concluding reflection

Working on both projects simultaneously has enabled me to see the myriad uses that bacteria have in ecosystems, and has shown the potential harm that bacteria can have on people. Concurrent work on these projects has allowed for a view of how bacteria, which is responsible for many infections, and the degradation and decomposition of food and perishable goods, can perform necessary jobs in the ecosystem and can be harnessed to perform seemingly insurmountable tasks. Researching both topics has shown how exceptionally adaptable and durable bacteria are; they are prolific and are the foundation of many ecosystems, they can readily survive extreme environments and have been shown to quickly adapt to unfavorable conditions developing antibiotic resistance and a resistance to copper surfaces. Additionally, they are an essential part of most organisms and are a critical in maintain the human digestive system. Overall, working on both projects together has allowed for a more complete study of bacteria's uses in science and methods to utilize and control bacteria.

References

Data Portal. (2018, October 5). CDC. Retrieved October 30, 2019, from https://www.cdc.gov/hai/data/portal/index.html.