Sustainable Disposal of Silicone Tubing in Hospitals
(Technical Project)

Assessment of Waste Infrastructure at UVA Health
(STS Project)

A Thesis Prospectus
In STS 4500
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 Biomedical Engineering

By
Anne Clements

October 27, 2023

Technical Team Members:
Margaret Weber, Davis Young

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.

ADVISORS

MC Forelle, Department of Engineering and Society

Zackary Landsman, Department of Systems Engineering

Introduction

Both waste and the management of waste have existed for thousands of years. Prior to the late 1800s, waste in the United States was considered something of value; it was recovered as fertilizer for the growing agricultural industry and materials for rags, bones, and paper (Barles, 2014). But, as the amount of waste increased as a result of rapid urbanization and industrialization, the quality and quantity of usable materials diminished. As waste management transitioned from recovery to disposal, the effects of widespread industrialization and consumerism intensified during the Second World War, significantly increasing the amount of waste being produced and the cost of waste sorting and recovery (Barles, 2014).

In the second half of the 20th century, the implications of the disposal of waste were exemplified through water and air pollution. Scientists began to examine the environmental impacts of the expanse of waste that was growing exponentially and the federal government passed several policies establishing uniform standards regarding pollution, motivating industries to dispose of their waste in landfills, rather than through incineration or ocean dumping (Tarr, 1985). "Sanitary" landfills were adopted by industries and municipalities as their primary disposal method and still serve as the predominant waste management system today in the United States (Tarr, 1985). Landfills, however, do not prevent hazardous materials (in their disposal and their deterioration) from excreting into the soil and, farther downstream, sources of water.

Municipal recycling was adopted nationally after waste recovery efforts were determined to be too labor and cost intensive, but the problem of waste was too apparent to ignore. It has been encouraged as an act of saving the environment, as greenwashing, the misrepresentation of how a company's products are environmentally sound, and single-stream recycling have decreased waste collection costs and increased recycling accessibility (Dahl, 2010). The switch to single-stream recycling, however, has led to a significant number of contaminated materials, higher sorting costs, and a reduction of overall quality in recyclable materials. The quality of the recycling decreases significantly as more materials are being recycled, to the point at which recycled materials are not able to be recycled further and are thus included in a waste stream (Wilcox et al., 2009).

Based on these historical perspectives, industrialization and consumerism in modern America exemplify the noncyclical nature of waste: raw materials are extracted from the earth, produced and manufactured into products to be sold, used once, and returned to landfills as waste. Modern production is focused on creating commodities and stocks that serve a singular purpose and one-time use. Media, scientists, and politicians argue that the global society, mostly participants in wealthy countries, are to blame for the environmental crisis at hand. Consumers purchase things with excessive plastic packaging, as industrial processes emit over 3 gigatons of equivalent carbon dioxide per year (*Historical GHG Emissions*, 2023). Globally, there is too much waste being produced and not enough is able to be recovered for reuse or refinement. The general opinion, however, reflects an "out of sight, out of mind" mentality: the issues involving waste and waste management are inapplicable to the average person if they are not directly affected (Müller, 2016).

Issues regarding waste and waste management are further exemplified in the University of Virginia Health System: products are used once, then placed into a stream of waste out of the hospital, rather than being re-sterilized for medical reuse or material refinement, while facilities management personnel are largely overlooked. My technical project focuses on the physical aspect of waste: the diversion the silicone tubing waste stream from the University of Virginia

(UVA) Hospital through the development of a comprehensive sterilization and reuse/refine/recycle procedure in order to reduce the amount of waste contributed by UVA Hospital to state, national, and global landfills. My STS project focuses on the social and ethical aspect of waste: the exploration of waste as an infrastructure through the perspective of facilities management personnel at UVA. The full-bodied investigation of both the physical and social components of waste and waste management at UVA, specifically at UVA Hospital, will provide an all-encompassing perspective of how waste affects the whole of the UVA community.

Technical Topic

In 2017, the EPA estimated that the United States generated 292.4 million tons of waste per year, a number that significantly increased since the COVID-19 pandemic (US EPA, 2017). Out of the almost 300 million tons of waste produced in the US in 2017, 6 to 9 million tons were generated by hospitals. Of this waste, about 85% is non-hazardous, and of this non-hazardous waste, a significant amount of it is recyclable (Janik-Karpinska et al., 2023).

UVA Hospital generates about 8 million pounds or 4000 tons of waste per year (calculated using Jain & LaBeaud's metric of 33.8 pounds of waste per day per bed and UVA Health's current bed statistic) (*Facts & Statistics*, 2023; Jain & LaBeaud, 2022). Unfortunately, the University lacks the infrastructure to recycle the majority of this waste, and, instead, it is heat sterilized and outsourced to other global recycling facilities or landfills or incinerated, which may produce hazardous emissions. Regulated medical waste (RMW) may also be disposed of as solid waste by mistake, which means that some hazardous materials may not placed in the proper waste stream, potentially infecting the personnel that handle it and the environment it is disposed into.

Medical supplies are high value products, so the opportunity to reuse them as intended or as material for other products is invaluable. The Medical Equipment Recovery of Clean Inventory (MERCI) Program at UVA Hospital collects medical supplies that are out of date, not returnable, open and unused, or deleted from inventory, including, but not limited to, surgical supplies and tools, office supplies, small medical supplies, and potential research laboratory equipment (*Recycling Medical Supplies: Reducing Waste*, 2023). Though MERCI has grown since its establishment, it is still restricted to the number of items it can accept and limited by its volunteer-run coordination. Ideally, the program would have a larger reach within the hospital, be able to accept more items, even clean dirty supplies. In principle, as well, manufacturing would shift towards the creation of products that are meant to be reused, especially within the hospital, so that less material is entering the waste stream altogether.

The primary goal of my team's technical project, then, is to develop a process to efficiently manufacture a usable material from an existing waste stream from UVA Hospital and divert the waste stream towards reuse or refinement, rather than the landfill. We are focusing on the silicone tubing used for air and fluids in the hospital. We hope to develop an efficient and sustainable method for the collection and diversion of silicone tubing through discussion with hospital staff and facilities management personnel and completion of Life Cycle Assessment (LCA) of the silicone material used. We will then alter the current waste stream to allow for sustainable disposal by healthcare system staff. After a collection method is developed, we will produce a feasible and efficient sterilization procedure that will allow us to perform an environmentally sound degradation process. We will experiment with multiple sterilization processes and conditions, most likely with the use of an autoclave, and measure the success of the method by a measurement of Sterility Assurance Level (SAL) and the contamination percentage of a culture from the interior and exterior of an autoclaved tube. The ideal sterilization technique will produce a low SAL and no bacterial contamination, but realistically, we will accept a value equal to or less than 1%. We also require the sterilization procedure to be feasible for the average user. For this process to be worthwhile, it must be both easy to administer within a healthcare setting, cost efficient, and timely. Once we determine an accurate and successful sterilization method, we will design and create a product, medical or otherwise, with the sterilized, refined material.

Our technical project will develop a procedure for sterilizing and degrading silicone tubing into a usable material for further use, extending the life of a current single-use plastic. By diverting this waste stream in UVA Hospital, we hope to diminish the amount of waste contributed to landfills worldwide, create a product fulfilling a current gap in the market, and create a procedure that can be implemented at a larger scale in many healthcare systems.

STS Topic

In “The ‘Flying Dutchmen’: Ships’ Tales of Toxic Waste in a Globalized World”, Simone Müller (2016) describes the role of “ghost ships” or “Flying Dutchmen” as vessels for the disposal of waste, unwanted on the lands they originate from in the seventeenth century and, later, the late twentieth century. These ships “discarded” sick people during large outbreaks of disease and, later, toxic materials into the ocean. The deployment of these ships and the lack of care after the cargo had been discarded emphasizes a greater issue regarding waste in the global industrialized community: the “out of sight, out of mind” mentality (Müller, 2016). In *Discard Studies*, Liboiron and Lepawsky (2022) explain, “We are familiar with some aspects of waste because we deal with it every day. Yet, […] many aspects of waste are entirely hidden from common view, including the wider social, economic, political, cultural, and material systems that shape waste and wasting" (p. 2).

First, I will situate waste management as an infrastructure, as per Star's qualities of an infrastructure: embeddedness, transparency, scope, is learned through membership, links with conventions of practice, embodies standards, is built on an installed base, is visible upon breakdown, and is fixed in increments (Star, 1999). Waste management, as it exists today, was built upon the systems in place of material recovery prior to landfills, as explored in the introduction. It is situated within existing systems of overlapping infrastructures, most notably in buildings like hospitals with designated areas for specific types of waste and doors and areas meant for the transportation of waste. There are embedded systems within waste management: individuals as actors; waste management personnel as collectors and sorters and transporters as actors; the political systems that create legislation determining how waste is handled as actors; the economic and social systems that create supply, demand, and production as actors. The organization of waste is learned through community members and other actors; in hospitals, there are guidelines a nurse must learn during their clinicals about where contaminated materials must go. Of course, waste management systems are potentially detrimental to intersecting systems if broken – the overflow of waste impacts the cleanliness and function of physical spaces.

In exploring waste as infrastructure, I propose a two-fold methodology to answer the question: How does the current management of waste at UVA Hospital affect our community, especially those in facilities management who are directly handling it? The management of waste at UVA Hospital is crucial to the functioning of the hospital itself but has been overlooked historically. The first method of assessing social attitudes towards the whole of waste in the current society, I will investigate the ethics of waste, through a literature review of several books including, but not limited to, *Discard Studies* by Max Liboiron and Josh Lepawsky (2022) and *The Ethics of Waste* by Gay Hawkins (2005). These readings will help me to construct an idea of the social, political, ethical, and power structures and dynamics that influence how "the average citizen" views waste. After such research, I will interview hospital staff and facilities management personnel at the University of Virginia Hospital on their perspectives of waste management, including their opinions on waste and waste management. I hope to also discover what happens to waste when it leaves the facility. The exploration of waste management as an infrastructure, specifically here at UVA Hospital, will provide broader context to how waste is created, produced, and managed.

Conclusion

In my technical project, my group and I will be developing an effective and efficient method for the sterilization and refinement of silicone tubing and products made from the refined material to divert the tubing waste stream from UVA Hospital waste treatment and landfills to reuse. Our hope is that this procedure and methodology can be implemented within UVA Hospital, as well as for other plastic and non-plastic products and in other healthcare systems. My STS project will provide context to design engineers and manufacturers in their creation of products and devices, hospital staff who interact with waste after use, and waste management personnel. The combination of these two projects addresses several aspects of the waste lifecycle in the hopes of decreasing the amount of waste being produced by UVA Hospital and providing context to how products should be designed and how waste is handled.

References

Barles, S. (2014). History of Waste Management and the Social and Cultural Representations of Waste. In M. Agnoletti & S. Neri Serneri (Eds.), *The Basic Environmental History* (Vol. 4, pp. 199–226). Springer International Publishing. https://doi.org/10.1007/978-3-319-09180-8_7

Dahl, R. (2010). Green Washing. *Environmental Health Perspectives*, *118*(6), A246–A252. https://doi.org/10.1289/ehp.118-a246

Facts & Statistics. (2023). UVA Health. https://uvahealth.com/about/facts-stats

Historical GHG Emissions. (2023). Climate Watch. https://www.climatewatchdata.org/ghg-emissions?breakBy=regions&chartType=line&end_year=2018&regions=WORLD&sectors=industrial-processes&start_year=1990

Jain, N., & LaBeaud, D. (2022). How Should US Health Care Lead Global Change in Plastic Waste Disposal? *AMA Journal of Ethics*, *24*(10), E986-993. https://doi.org/10.1001/amajethics.2022.986

Janik-Karpinska, E., Brancaleoni, R., Niemcewicz, M., Wojtas, W., Foco, M., Podogrocki, M., & Bijak, M. (2023). Healthcare Waste—A Serious Problem for Global Health. *Healthcare*, *11*(2), Article 2. https://doi.org/10.3390/healthcare11020242

Liboiron, M., & Lepawsky, J. (2022). *Discard studies: Wasting, systems, and power*. The MIT Press.

Müller, S. M. (2016). The “Flying Dutchmen”: Ships’ Tales of Toxic Waste in a Globalized World. *RCC Perspectives*, *1*, 13–20.

Recycling Medical Supplies: Reducing Waste. (2023). UVA Health. https://uvahealth.com/services/community-relations/recycling-medical-supplies

Star, S. L. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist*, *43*(3), 355–492. https://doi.org/10.1177/00027649921955326

Tarr, J. A. (1985). Historical Perspectives On Hazardous Wastes in the United States. *Waste Management & Research*, *3*(1), 95–102. https://doi.org/10.1177/0734242X8500300111

US EPA, O. (2017, October 2). *National Overview: Facts and Figures on Materials, Wastes and Recycling* [Overviews and Factsheets]. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

Wilcox, J., Collins, S., McLaughlin, B., & Morawski, C. (2009). *Understanding Economic and Environmental Impacts of Single Stream Collection Systems*. Container Recycling Institute. https://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf