Undergraduate Thesis Prospectus

Sustainable Disposal of Silicone Tubing in Hospitals

(technical research project in Biomedical Engineering)

Inconvenient Sustainability: The Uphill Battle of Recycling in the U.S.

(sociotechnical research project)

by

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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.

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General research problem

How may the volume of unrecycled waste be diminished?

America generates an estimated 292.4 million tons of waste per year, half of which goes to landfills (EPA, 2018). Landfills emit large quantities of greenhouse gases, such as methane and carbon dioxide, which contribute to global warming. Richburg proposes harnessing these gases and decreasing waste through recycling methods and more effective waste infrastructure (2023). Yet waste continues to build up on mountains of trash and on the sides of roads as the battle of social implications of waste disposal and lack of waste infrastructure are at odds with one another (Reno, 2015). America and the rest of the world have begun to recognize the negative environmental impacts of waste production, and so a desperate rush has begun to reverse the effects. But will there be enough time before irreversible damage ensues?

Sustainable Disposal of Silicone Tubing in Hospitals

How can silicone tubing in hospital systems be disposed of sustainably?

This problem will be investigated by a team of Anne Clements, Maggie Weber, and me via a Biomedical Engineering Capstone project advised by Zackary Landsman.

Hospitals in the U.S. generate approximately 33.8 pounds of waste per day per patient leading to about 6 million tons of waste annually. About 85% of this waste is non-hazardous, and of this non-hazardous waste, a significant amount of it is recyclable (Jain & LaBeaud, 2022). The current infrastructure lacks the ability to recycle the majority of this waste and, instead, is sent to landfills. Yet minimal efforts are being taken to create actionable steps for the environmental disposal of hospital waste. The American Public Health Association (APHA) hasn't posted a policy statement explicitly about waste as a public health issue since 1986 and continues to overlook healthcare's millions of tons of waste produced each year (Canate et al., 2023).

Silicone tubing is just one of many hospital products that end up in landfills, yet has much potential for sustainable recycling and reuse, which our team will focus on. We calculated that the UVA Health system produces over one million pounds of tubing per year, costing almost $2.5 million (USP, 2023; UVA Health, 2023).

As we seek to mitigate some of the current environmental and economic damages of the tubing industry, we will begin by (1) analyzing the UVA hospital system waste stream and designing a more sustainable waste flow system whereby silicone tubing is reused and disposed of in a safe and environmentally sound manner. Then we will (2) develop a sterilization procedure to decontaminate the tubing which will allow for (3) the breakdown of silicone tubing via cutting and heating measures. This will create the material to (4) design and create a medical device using the broken-down silicone. The most significant limiting factor constraining our project is that only certain hospital waste is available for us to examine due to it hazardous nature.

The primary recycling and reuse initiative in UVA hospitals is led by the Medical Equipment Recovery of Clean Inventory (MERCI). MERCI is cost-free to the UVA hospital and collects sparsely to never used waste products that have no contamination. Hospital volunteers sort and organize through the supplies on Thursdays and permit hospital staff to grab and reuse the equipment collected. They also distribute materials to humanitarian organizations and send supplies to specialists in the Charlottesville area to recycle. They only receive a fraction of the total unused waste in the hospital since they are a small volunteer network and only certain departments participate in dropping off reusable supplies (MERCI, 2023). Additionally, silicone is extremely difficult to break down due to its high melting point of 450°C (842°F). The two main methods of silicone recycling are compression molding and extrusion. Compression

molding melts the silicone into a mold to form a new shape. Extrusion melts the silicone and pushes it through a dye, creating pellets. These pellets can be used as the material for a new product or turned into silicone oil, which is used as a car lubricant. Both of these procedures can only be conducted at specific recycling facilities which are limited in the U.S. (Stephanie, 2022).

Interviewing the UVA hospital staff will be the preliminary measure for collecting qualitative and quantitative data about the current waste flow of the UVA hospital as a whole and the waste flow of silicone tubing more specifically. This will allow us to generate models of the current silicone tubing waste stream and convert this model into a more sustainably viable model. We will measure the effectiveness of this model in silicone tubing waste diverted in pounds, which is the weight of tubing no longer being sent to landfills.

An autoclave will be used as the primary means of sterilization where we will measure the sterility assurance level (SAL) and the contamination percentage. After sterilization, we will swab the interior and exterior of the tubing and culture the samples. The ideal sample will produce no bacterial contamination, measured by percent confluence of the culture. SAL is the probability that a material that has undergone sanitation will still remain unsterile. The SAL will be determined by taking a random sample of these cultures and computing the probability that any sample could be contaminated after going through the sterilization process (Denyer, Norman, Gorman, 2004).

We will measure the length of time the autoclave takes to sterilize the equipment as well as the length of time to manufacture a medical device product to ensure realistic implementation of these measures. The yield of silicone tubing turned into filament and the economic value diverted will also be calculated in conjunction with weight diverted to determine the impact of our project upon the UVA Health system.

This project seeks to yield a reduction in silicone tubing in landfills, a procedure for reusing silicone tubing, and a procedure for converting silicone tubing into a new product. This will increase the environmental sustainability of the silicone tubing waste cycle, but more importantly will set a precedent for how the readjustment of waste disposal techniques and protocols in hospitals can have monumental impacts upon the social culture and norms of environmental and economic sustainability.

Inconvenient Sustainability: The Uphill Battle of Recycling in the U.S.

How do advocates of sustainable waste disposal promote recycling in the U.S.?

Of the 650 billion pounds of waste America produces each year, only a third is recycled (EPA, 2018). Recycling efforts in America have significantly improved in the modern eye from the 1970s, the proclaimed origin of American recycling. On the contrary, the 1970s marked a transition period in recycling from seeking to get the most out of materials, to dealing with "the massive amounts of waste produced during the second half of the 20th century" (Waste360, 2023) This shift directs advocates of sustainable waste disposal towards sustainability damage control.

Researchers have investigated how recycling is impacting America's waste disposal infrastructure and environmental sustainability. For instance, Begum and Ehsan found that the U.S. and other developed nations have started to change from a linear economy: make, use, and dispose; to a circular economy: make, use, and recycle (2020). Dahl presents that this is increasingly difficult due to greenwashing, which is the miscommunication of sustainable recycling measures in packaging, advertisements, and legislature. The Federal Trade Commission (FTC) has taken steps forward by releasing the Green Guides, which outlines the

illegality of marketing misdirection, but the document still has a lot of loopholes that marketers exploit (2010).

Carlson, on the other hand, explores how social norms influence people to recycle out of community pressures, financial impacts, and government influence (2001). Abbott, Nandeibam, and O'Shea further this concept by exploring how recycling is impacted by social norms and warm-glow, the personal satisfaction received from an activity independent of its impact, and how these two factors can motivate individuals to recycle more frequently if the quality of recycling facilities is improved. They concluded that social norms had a greater impact than warm-glow, and that the community had a greater influence upon recycling norms than government monitoring and enforcement (2013).

Participants include the National Waste & Recycling Association (NWRA), which is a trade association that represents waste and recycling companies, manufacturers, and distributers. For example, the NWRA applauded the reintroduction of bipartisan legislature that would "improve rural recycling accessibility and data collection for recycling and composting" (NWRA, 2023). Waste Management (WM) is a waste management, comprehensive waste, and environmental services company. Last month, they unveiled a new $30 million recycling facility in Ohio as they seek to "drive circularity and help give materials a second life" as part of their commitment to spend over $1 billion in recycling infrastructure by 2026 (WM, 2023). Subaru, an automobile manufacturer, is partnered with TerraCycle, a recycling business, allowing customers "opportunities to recycle with their local, participating Subaru retailer" (PR Newswire, 2023).

The International Brotherhood of Teamsters, known as the Teamsters, is a diverse labor union that represents a large number of industries, including the Solid Waste and Recycling Division. The Teamsters signed a contract at Ridwell, a recycling startup in Seattle, increasing

wages, improving work conditions, and providing paid time off. Though Ridwell is a small company now, the Teamsters highlight that they will "employ hundreds, if not thousands, of workers in the industry" and by signing this contract, Ridwell and the Teamsters set a healthy work culture precedent in the continual push for recycling sustainability (IBT, 2023).

Container Recycling Institute is an advocacy group lobbying support for recycling legislature and leading recycling education across America, including "recycling deserts in the state" of California and the need for recycling accessibility (Pyzyk & Rosengren, 2020). The University of Virginia's Office for Sustainability is also an advocacy group within the university which leads environmental sustainability efforts at UVA and in Charlottesville. Some of their more ambitious goals include "eliminating single-use plastics, expanding zero-waste events and increasing recycling bin locations" (Madren, 2020).

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