A Circular Economy for O‘ahu’s Management of Single-Use Plastics

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ABSTRACT

Ever since Single-Use Plastics (SUPs) became a ubiquitous part of our daily lives, societal emphasis has generally been on downstream management – such as recycling efforts and cleanups – of SUP waste. Less attention has been given to upstream management, such as extended producer responsibility (EPR), assigning producers the stewardship responsibility at the end-of-life of their products. Life cycle assessment (LCA) is helpful in initiating upstream management by assessing the ecological impact at every stage of a product, from the extraction of raw materials to packaging and use to the end-of-life management. Understanding the life cycle of SUPs is critical to mitigating the unsustainability issues that SUPs create. The complexity of SUP pathways across human settlements makes it difficult to conduct LCAs as precursor to designing and realizing a more circular economy. Thus, island settlements may provide insightful implications due to fewer points of SUP entry and removal than vast, interconnected continental communities. Therefore, islands may serve as useful models to investigate, critique, and address negative externalities revealed by LCAs. This study focuses on the island of O‘ahu in the state of Hawai‘i and a simplified life cycle assessment is conducted for the most prevalent SUPs. After quantitative and qualitative data are analyzed, circular economy approaches for SUP management on the island are identified, described, and assessed for applicability to O‘ahu’s context.

Introduction

Single-Use Plastics (SUPs) – plastic bags, bottles, wrappers, etc. – have become one of the most challenging contemporary environmental issues in recent years (World Economic Forum et al., 2016). Most of the plastic pollution in the ocean is from SUP waste (McDermott, 2016). These plastics are manufactured to be durable, which also make them difficult to biodegrade. While discarded or littered SUPs remain in the environment for at the least 10 to 20 years (Marine debris, n.d.), many parts of the ecosystem, including wildlife and human life, are harmed (Rodrigues et al., 2019). On top of that, most SUPs are made from petrochemicals, a nonrenewable resource, for which extraction and processing into SUPs also have negative ecological externalities (The Plastic-Production, n.d.). Thus, harm emerges at each stage of an SUP product’s linear lifecycle: resource extraction, product production, and disposal as waste.
“In a circular economy, by contrast, we stop waste being produced in the first place,” states the Ellen MacArthur Foundation (n.d.), a charity committed to creating a circular economy. According to the Foundation, three actions are required to achieve a circular economy for SUPs: (1) eliminating unnecessary plastic items, (2) innovating to ensure that the plastics we do need are reusable, recyclable, or compostable; and (3) circulating all end-of-use plastics to keep them in the economy and out of the nonhuman environment. It is also important to increase the resource-efficiency of products that cannot yet be readily re-designed to be reusable, recyclable, or compostable (Plastics and the circular, n.d.).

Although there are numerous existing studies on the life cycle or parts of the life cycle of SUPs, few studies focus on a specific geographic region. Conducting location-specific LCA is critical as it provides a more accurate estimate of location-specific upstream and downstream management of SUPs. Furthermore, the more studies there are on various regions across the globe, the better we can understand commonalities and together drive global trends

towards a circular economy for SUPs. The LCA in this study looks at the input and output material flow of SUPs on the island of O'ahu in Hawai'i, USA to identify and address gaps between the current situation and an ideal circular economy for SUPs on the island.

Table 1. Single-Use Plastics (SUPs) included in the focus of this study. Single-use consumer products presented in columns one and two are composed of plastic resins, with Resin Identification Codes (RICs) shaded in the third column of each row.

SUP Product	Examples	Resin Identification Code
Plastic Bags	• Grocery bags • Shopping bags • Ziploc bags • Trash bags	
Plastic Bottles (beverage)		
Plastic/Foam Food Ware	• Hot and cold beverage cups • Cup lids • Plates • Bowls • Take out "clamshells"	
Plastic Service Ware	• Utensils • Straws • Stirrers	
Plastic Food/Product Wrappers	• Chip bags • Cling wraps • Toilet paper packaging	
Plastic Food/Product Containers	• Produce "clamshells" • Yogurt containers	

Methods

SUPs examined in this study were mainly packaging, categorized according to Table 1. This table distinguishes by row six types of consumer products, such as plastic bottles and food wrappers. Each of these product types may be made from one or more of seven types of potentially recyclable plastic resins (Resin Identification Codes 1 through 7). Each product and resin could have a distinct linear ("cradle-to-grave") and/or circular ("cradle-to-cradle") pathway through a particular economy.

For vast continental economies, tracing SUP material flows along all of these pathways through a metropolitan region is a daunting task. Instead, we focused here on using a comparatively simple, urban island economy - O'ahu, Hawai'i – as a model to assess and propose improvements to the metropolitan-scale circularity of SUP lifecycles. The current states of O'ahu's SUP import, export, and management on the island were compiled and analyzed using existing data. These findings were then used to identify gaps between the current state and an ideal circular system for SUPs on the island. Assessment of a circular economy for SUPs follows guidance from the Ellen MacArthur Foundation (World Economic Forum et al., 2016). The three pillars to realize a circular economy for SUPs – eliminate, innovate, and circulate – were applied to O'ahu's context, considering its geographical location, culture, and needs. After presenting these results below, we discuss the insights, implications, and limitations of this study for advancing the circular economy of SUPs on other urbanizing islands and across larger, more complex metropolitan regions.

O'ahu's Current Management of SUPs

We estimate that O'ahu imports at least 100.2 U.S. kilotons (kt) of SUPs each year. Most SUPs arrive via ship from East Asia. Although there is on-island production of SUPs such as plastic bags from imported resins, the quantity is unknown and thought to be relatively minor.

According to a 2017 Waste Composition Study by the City and County of Honolulu (a.k.a. the island of O'ahu), plastics were 9.8% of total waste (by weight) generated on the island (Figure 1). This includes municipal solid waste disposed of at H-POWER waste-to-energy plant and at the Waimanalo Gulch Landfill. This includes waste from four sources – residential, commercial, residential self-haul, and commercial self-haul. The 2017 study further revealed that 87% of this plastic waste were plastics #3-7 (Figure 1).

Regarding O'ahu's SUP outputs (Figure 2), only plastics #1 and #2 are accepted in the blue curbside recycling bins, while plastics #3-7 are considered as waste and placed in gray curbside bins. Plastics #1 and #2 are then exported and recycled overseas because there are no commercial recycling facilities on O'ahu. Plastics in the gray bins, meanwhile, are incinerated at the H-POWER waste-to-energy facility on the island. Plastics #3-7 are considered of low-grade and low-value, providing greater net benefit in local energy production than in shipping to distant markets to be made into new products (H. Gabriel, personal communication, February 15, 2022).

Leakage in the context of plastic waste refers to plastic waste not making it to the collection system or escaping the collection system. The magnitude of plastics #1-7 leakage into the environment was estimated using the Ellen MacArthur Foundation's datum that "an estimated 32% of plastics escape the collection system globally – that is, either it is not collected at all, or it is collected but then illegally dumped or mismanaged" (World Economic Forum et al., 2016). The product of that coefficient and total SUP imported to the island suggests roughly 32.1 kilotons of SUPs are leaked into the environment every year.

O'ahu's SUP inputs were triangulated based on two estimates. The first method simply summed known outputs. In other words, since 100.2 kilotons per year was identified as the minimum SUP output from the island, there must at least be 100.2 kt per year of SUP inputs. The second method utilized Hundertmark and others' (2020) finding that "on average, Americans consume 100 pounds per person, per year, of packaging and food-service plastics" (Hundertmark et al., 2020). Since O'ahu's population is about 953,207 people, the island's annual consumption of

packaging and food-service SUPs was calculated as being 95,320,700 pounds or 47.7 kt. The island of O‘ahu has a higher plastic consumption than the national average (N. Chatterson, personal communication, April 20, 2022), which can be attributed to the prevalence of SUPs in the tourism industry and the island’s heavy reliance on imports, in which pre-packaged items are packaged further for shipping. In order to avoid underestimating SUPs in need of management on the island, we use the larger two estimates for subsequent analysis below.

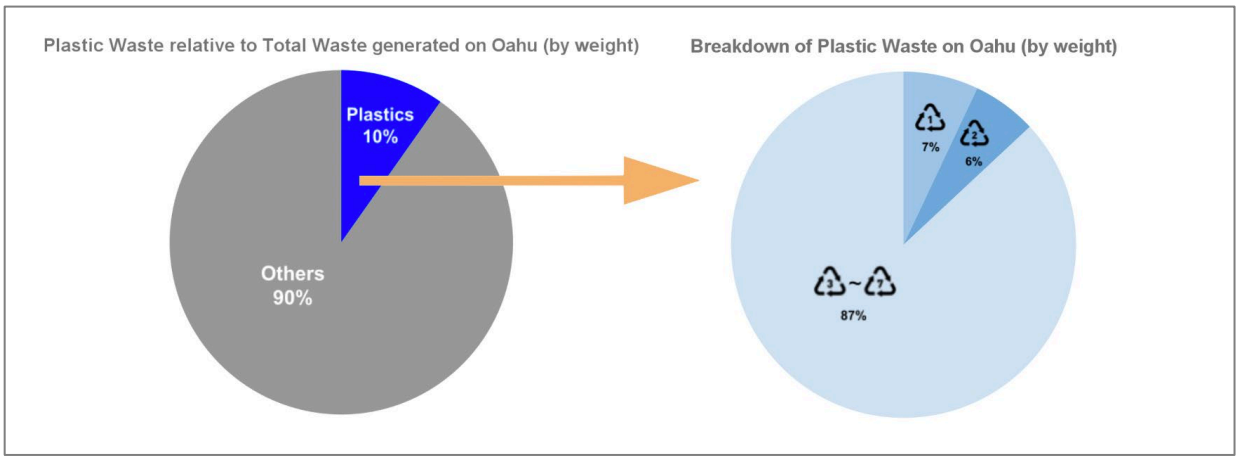

Figure 1. Breakdown of plastic waste generated on O‘ahu

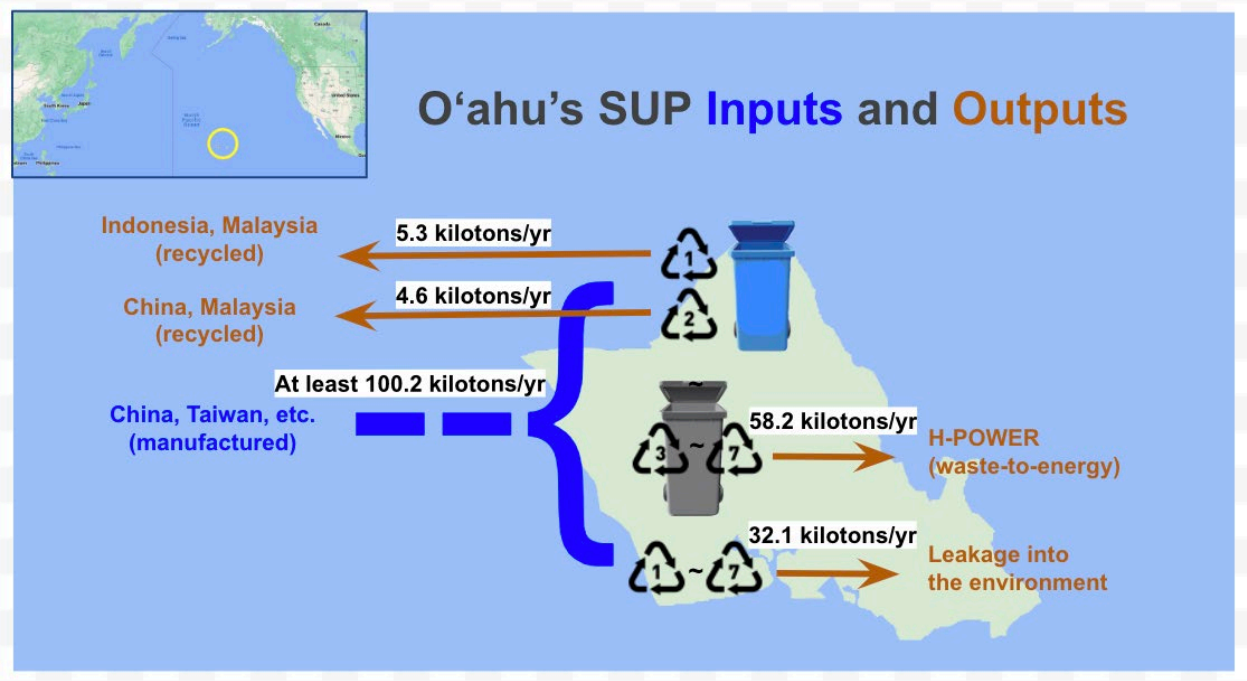

Figure 2. O‘ahu’s SUP Inputs and Outputs – Information retrieved from the City and County of Honolulu’s 2017 Waste Composition Study, Henry Gabriel, Honolulu Recycling Branch Chief, and the Ellen MacArthur Foundation.

Applying the Circular Economy Approach to O‘ahu’s Context

The inventory and mass balance analysis above revealed O‘ahu has a largely linear economy with respect to single-use plastics. After SUPs arriving from East Asia are used on the island, the vast majority is incinerated (58.1%) while

a substantial amount is leaked (lost) to the environment (32.0%). A small remainder (RICs 1 and 2) is of sufficient quality and demand to make it worth shipping back to Asia for recycling (9.9%).

The municipal government and its partners appear to recognize there are opportunities to promote a more circular economy. Using the Ellen MacArthur Foundation's tripod conceptual framework provided, we present below an organized set of recent local actions and supplementary recommendations that could facilitate Honolulu's intentional pursuit of a circular economy for all SUPs:

1. **Eliminate** unnecessary plastic items

The County's Disposable Food Ware Ordinance (n.d.), effective January 2022, restricts the use and sale of disposable food and service ware made of plastics, including polystyrene foam (RIC #6). Specifically, the ordinance requires that:

> No food vendor shall sell, serve, or provide prepared food in polystyrene foam food ware or disposable plastic food ware to customers.
>
> No businesses shall sell polystyrene foam food ware, disposable plastic service ware, or disposable plastic food ware.

This increased regulation of SUPs on O'ahu is an important step forward in eliminating unnecessary plastic items. Since only a few months have passed since this regulation came into effect, more time is needed for quantifiable results on the amount of SUP waste mitigated by the ordinance. Nonetheless, successful municipal campaigns to eliminate plastic straws (RIC #5) and plastic grocery bags (RIC #2) elsewhere, such as Washington, DC (Our last straw, n.d.; Purpose and Impact, n.d.) suggest that O'ahu need not wait for full polystyrene elimination before acting to eliminate other plastic resins used on the island.

2. **Innovate** to ensure that the plastics we do need are reusable, recyclable, or compostable

There is a need for more reusables to replace SUPs #3-7 on O'ahu since recycling these resins is not an economically feasible option. Many SUPs #3-7 are food ware and service ware within the food service industry. When introducing food ware and service ware made of alternative materials, potential unintended consequences must be evaluated. Reusable innovations should be prioritized while passing the difficult-to-reuse scenarios to recyclable or compostable innovations. Consider Zero Waste O'ahu's current "Full Cycle Takeout" pilot program, partnering with five O'ahu restaurants. Customers at those restaurants can participate in a reusable takeout container program for free, instead of using single-use plastic takeout containers (How It Works, n.d.).

Metal, paper, and pasta straws illustrate the variety of reusable, recyclable or compostable materials available to render unrecycled SUPs obsolete. Agricultural waste, such as sugarcane fiber, may also serve as a substitute for SUP grocery or shopping bags (Sugarcane Fiber, n.d.).

SUP waste-to-energy is not a long-term solution that supports a circular economy (Ellen MacArthur Foundation, n.d.). Getting rid of plastic waste via incineration gives a misleading sense that SUPs are not a problem. First, 99% of plastics are made from petrochemicals; depleting a nonrenewable resource is not circular. Furthermore, energy recovery from incinerating plastics is a last resort option, as the energy extrapolated from combustion is merely the amount of energy inputted to produce and manufacture SUP products. In other words, as the Ellen Macarthur Foundation says, "while recovering energy is a good thing in itself, this process still loses the embedded effort and labor that went into creating the material." Another issue with being dependent on getting rid of plastic waste in mixed solid waste incinerators is that it can create a 'lock-in' effect. As the Ellen MacArthur Foundation states, "the large capital investments but relatively low operating costs involved in building up and running such infrastructure can effectively

push higher-value mechanisms such as recycling out of the market." There is also a concern of the greenhouse gas emissions and pollutants that are released into the atmosphere after combustion (World Economic Forum et al., 2016).

The European Commission (2017) described the role of waste-to-energy in the circular economy, stating waste management principles that prioritize prevention, preparation for reuse and recycling over waste-to-energy. This hierarchy should be implemented on the island of O'ahu as well.

3. **Circulate** all end-of-use plastics to keep them in the economy and out of the environment

While there are SUPs in circulation that are labeled compostable, there is currently no industrial composting facility on the island where compostable SUPs can be handled. Therefore, compostable SUPs are treated as regular trash and are either incinerated or landfilled. One barrier to advancing the establishment of a facility is the presence of enduring, harmful chemicals called Per- and Polyfluoroalkyl Substances (PFAS) in some SUPs (Environmental Protection Agency, n.d.). Since PFAS does not go away unless burned at high heat, composting SUPs with PFAS would mean PFAS accumulate in the compost. Further technical research on PFAS is in the progress. Creating an industrial composting facility for compostable SUPs will also require local political will that has not been present so far (H. Gabriel, personal communication, May 31, 2022).

Extended producer responsibility (EPR) will be crucial in catalyzing this "circulate" pillar. With an emphasis on EPR, businesses producing and/or selling SUPs will have a responsibility beyond the design, sale, and use of their SUPs, and will contribute towards it being collected and reused, recycled, or composted in practice (World Economic Forum et al., 2016).

In addition, strategically placing and maintaining more recycling bins in public spaces where littering occurs a lot could make a big difference in reducing what we estimate to be huge "leakage" loss to the otherwise idyllic Hawai'ian ecosystem. These spaces could include beach parks, parking lots, and popular tourist and hangout spots around the island.

Lastly, continued social marketing – awareness-raising outreach, education, and civic action – should emphasize the "win-win" socioeconomic and ecological benefits from litter avoidance and actively fostering a more circular island economy.

Discussion

Less than 25% of plastics #1 and #2 on O'ahu are collected for recycling outside of Hawai'i. This is equivalent to about 10% of all SUPs arriving on the island each year. The rest is either incinerated or "leaked" to the environment. This is the antithesis of a circular economy for SUPs.

The majority of SUPs are incinerated at a waste-to-energy facility. According to the Ellen MacArthur Foundation, waste-to-energy is not a long-term solution that supports a circular economy. The fact that the majority (87%) of plastic waste on O'ahu is being incinerated highlights the need for a redesign. Specifically, higher-value mechanisms such as reusing and recycling need to be prioritized over the convenient option of incinerating.

Conclusion

All three pillars of eliminate, innovate, and circulate need to work on harmony in order to realize a circular economy for SUPs. Based on our analysis above of the current system on O'ahu, there are many opportunities to apply these pillars to transition the island from a predominantly "leaky linear" economy to a much more resource efficient, economically and environmentally conscious, circular economy. Top priorities should be to eliminate unnecessary SUPs, introduce reusable and compostable alternatives for SUPs #3-7, and to intercept SUP leakage into the environment. Integrated environmental, economic, and social policies should be considered, such as those embodied in the pursuit

of a circular economy. Implementing regulations and programs that push forward the three pillars of "eliminating, innovating, and circulating O'ahu's SUPs" will be key to the long-term outlook for a sustainable circular economy on the island, other island settlements, and urbanizing regions around the world.

Limitations

It is important to note that the percentages for the plastic waste generated on O'ahu are by weight and not by volume. In other words, this is a limitation since solely quantifying by the weight of plastic waste does not show the overall picture (N. Chatterson, personal communication, April 20, 2022). There remain gaps in the data and information presented in this study that can be addressed in future research. The inputs and outputs of SUPs on O'ahu can be further researched and refined. Future studies could also focus specifically on the economic trade-offs that result from the circular regulations and programs. In addition, while the topic of microplastics is related to SUPs, microplastics are not accounted for in this study due to its complexity and limited local data. Finally, as waste management methods differ from place to place, the inputs and outputs investigation method for this study may not be applicable for other geographic locations. For example, in states on the continental U.S., there will be more factors added to the material flow as there is movement between neighboring states.

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