The Trash is Piling Up:

Policy and Philosophical Responses to Limit Waste

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Introduction

Global production of waste totaled 1.3 billion metric tons in 2012 and is predicted to almost double to 2.2 billion metric tons by 2025 (Margallo et al., 2019). Around the turn of the century, U.S. municipalities produced 230 million tons annually, almost totaling to 1 ton per person on average, and this did not even account for 7.6 billion tons produced by industry (Sayre, 2010). An estimated 7 trillion plastic bags are used every year, and plastic waste can take up to 500 years to break down fully (Rajmohan et al., 2019). These numbers, considering the finitude of the Earth, are not sustainable figures; any discussion of environmental stewardship for our children and grandchildren must necessarily include a serious discussion on the management and limitation of waste products. This type of understanding must look past simplistic models for consumers such as the three R's (reuse, reduce, and recycle) to question our role in embedded structures and institutions based on economic growth, consumer demand, and marketing and seek complex policy and philosophical responses to limit waste.

Why We Produce So Much Waste

This staggering amount of waste might be thought of as essential means for human beings to live on the Earth, especially as there are now more than 7.5 billion people inhabiting the planet, resulting in the current magnitude of waste production. Indeed, in order for us to have life, we must extract an external supply of energy from our environment, sending back out entropy produced in the form of unusable thermal heat or degraded structures. Therefore, the production of waste is inevitable for life and sustenance, but the question then becomes what is the minimum amount of waste needed for a healthy life. Even though the population of humankind rose exponentially from 1750 to 1900 to the present day — resulting in increased energy use and therefore higher waste generation — there has also been an exponential increase in energy use per capita in this same timespan due to the expansion of the luxury market and industrial goods and devices offering comfort and convenience. This exponential use of energy and subsequent generation of waste is tied to the desire for wealth in capitalistic societies as well as the idea that economic growth is the prime goal for a nation's success. Economic growth is driven by an increase in wealth by all citizens, and wealth is driven by an increase in consumer demand spurred by corporate marketing in the greater production of goods, leading to increased biosphere degradation and greater production of wastes (Sayre, 2010).

This production of waste is stimulated by consumer demand focused on convenience and manipulated by marketing to shape preferences and create new needs. Sayre compares the interaction between consumer demand and production of goods to a drinking straw, where consumer demand drives further production of goods and not vice-versa, meaning that controlling consumer demand can potentially lead to higher production of goods and higher profits for corporations. To manipulate consumer demand, companies employ marketing techniques such as simple product presentation, targeting to specific audiences, redefining user's preferences, and neuromarketing. Just like the conditional response of Pavlov's dog to salivate whenever it heard the sound of a bell, marketing can reshape one's own needs, conditioning someone to associate favorable emotions with their product or even convincing them to have specific needs which only the company's product can satisfy. For instance, the consumption of soda, ubiquitous air conditioning, brand name clothing, and the newest smartphone were not enjoyed by the majority of the historical human race, yet many people today associate these products with "needs" in society, a conviction which is enhanced or entirely spurred by marketing. Neuromarketing studies in particular can track emotional responses to specific regions of the brain and adjust their marketing strategy for maximum consumer response. These two types of marketing contribute to the ever-increasing drive for production, which in turn increases the abundance of waste in our society (Sayre, 2010).

Our tendency toward abundant waste has roots in society's celebration of convenience and acquisition. After the industrialization of labor-saving appliances, our society celebrated a throwaway culture of convenience, embracing the manifold uses of single-use plastic and therefore shaping production to meet consumer demand for convenience (Sayre, 2010). Many societies have mutually accepted the usage of materials such as single-use plastics that will not break down in the natural environment for at most five centuries (Rajmohan et al., 2019). This convenience can be seen in consumer behavior as consumers choose to throw all trash in recycling containers instead of properly splitting up the trash or leave appliances or products running to not forsake convenience. It is seen as consumers are drawn to fast food restaurants or the allure of owning our own car. Furthermore, consumer demand drives us to continually buy new goods regardless of their actual need or use. The prime example involves scheduled sales at stores which drive consumers to buy a specific product at a certain opportune time; the goods are often not needed, but consumers are driven out of compulsion to not miss out on an opportunity. For instance, semi-annual or quarterly sales at department stores or fashion boutiques or even the allure of a sale makes consumers think of the acquisition of products as too good of a deal to pass up rather than considering if they actually need the product. With the rise of online shopping, this ability to push consumers to buy more goods is at the whim of a notification or an email showing the latest sale. Additionally, consumers face a social aspect named "conspicuous consumption." Coined by Thorstein Veblen, the term showcases that consumers are willing to buy unnecessary products to indicate their wealth and standing, with the more unnecessary purchase, the better. For instance, the obsession with designer-brand sneakers or collectables, not necessary to a fulfilling human life, is endorsed by celebrities, the elites of society, and then followed by the masses, all increasing production and therefore waste generation (Sayre, 2010).

Solid Waste Management Fundamentals

An overview of solid waste management would be helpful to ground understanding of the role of waste in society. This industry is comprised of various systems to deal with waste, including collection, sorting, transport, treatment, and disposal (Margallo et al., 2019). There is a general positive correlation between a country's GDP and its waste generation, with developed countries accounting for 40% of the world's waste, 37% for developing countries and 23% for undeveloped countries (Das et al., 2019). The constituents of the waste are made up of organics, cardboard and paper, glass, plastic, electronic waste, metals, and other materials; and its overall make-up follows general changes across country groups; countries comprising the Organization for Economic Co-operation and Development (OECD) have a higher percentage of recyclable material and a lower percentage of organics in the waste compared to non-OECD countries (Margallo et al., 2019). The majority of waste collection in the world (63% of all countries) is done through informal rag-picking by people not officially hired to collect trash. This is due to a lack of waste collection infrastructure and a lack of proper processing channels (Das et al., 2019), and there is a much higher rate of collection services in OECD countries (98%) compared to lower income countries (from 11 to 55%) (Margallo et al., 2019). The extent of solid waste management is determined largely by a particular country's economic level as determined by the ability to spend money for skilled labor or build up collection, transport, and treatment infrastructure (Das et al., 2019).

Knowing and forecasting the particular composition of the local waste stream is essential in determining the most cost-effective management strategy to treat the waste, whether that be deposition in a landfill, composting, or production of energy through thermo-chemical conversion or bio-chemical conversion (Das et al., 2019). For treatment in developed countries, the European Commission has set targets to limit landfill waste to a maximum 10% of total waste and to strive for 65% recycling for waste. In the U.S., landfilling still consitutes the majority of solid waste treatment at 53% of the total followed by recycling and composting (35%), although there have been strides in the past 15 years toward greater percentage of recycling and composting. Treatment in developing countries must also face improving conditions from merely unregulated disposal of waste in dumpsters, bringing greater environmental risks such as lack of biogas recovery and lack of treatment of the polluted leachate runoff going into the soil; in Latin America and the Caribbean, 33% of total waste is disposed of in this manner (Margallo et al., 2019). To compare different treatment methods in terms of which policy to pursue, cost-benefit analysis is employed to find the optimal use of limited funding, but many other nations have no substantial waste management program due to lack of legal frameworks in the form of incentives/prohibitions or due to the unenforceability of waste management laws. However, this type of practice has an economic basis by increasing the efficiency of resources to the economy, offering higher-quality materials for reuse, establishing jobs through each stage of the process, providing cleaner and easily accessible energy as a product of treating the waste, and encouraging greater investment in this sector through newer energy-producing and durable technologies (Das et al., 2019).

The practice of life-cycle assessment (LCA) is paramount to sustainable decision-making for solid waste-management, as it determines the environmental impact of any treatment technology from "cradle to grave." This tool has four major objectives: to describe any waste process, collect data, analyze the data and judge impact, and generate/obtain results (Das et al., 2019). Primary data is input into a specific model which outputs statistics such as carbon dioxide or methane emissions, soil quality, and amount of leachate (liquid waste) produced as well as effects on climate change, acidification, toxicity, and eutrophication (low oxygen levels due to decomposition of microorganisms) (Margallo et al., 2019). However, LCA assessments are mostly applied to developed countries rather than developing ones, prompting the future modeling of site-specific conditions within developing countries (Das et al., 2019). These assessments necessarily preclude information about the local site conditions in order to cover "spatial variability and local environmental uniqueness" — values that may not be known or able to be measured in developing countries due to lack of funding (Das et al., 2019). There is also limited use in translating the results of one community's LCA to another due to complex non-linear interactions in the two different environments potentially leading to different results as well as usually missing uncertainty analysis of the data found. Yet, this modeling tool allows for evidence-based policy decision-making and is therefore encouraged despite these drawbacks (Margallo et al., 2019).

Assessment of Various Wastes

Plastic waste consumption is projected to increase 5% each year, with 150 million tons produced annually and an estimated 65-70% ending up in waste disposals such as landfills. Plastic waste is essentially nonbiodegradable and its breakdown by manmade processes such as incineration can lead to the release of toxins such as dioxins and phthalates into the surrounding ecosystem. These toxins have health links to sexual diseases, endocrine disruptors, and cancer.

The recycling of plastics suffers from the challenges of producing actually nonbiodegradable plastics such as polyethylene and polyvinyl chloride; the mixing of recyclable plastics with other organic wastes and liquid, increasing the cost to separate these fractions and recycle the plastic; and minimal financial incentive due to closing international markets for any waste imports from China and Southeast Asia. Furthermore, there are limited studies for the life cycle assessment of plastic waste, especially in regard to interaction with riverine and oceanic environments (Rajmohan et al., 2019). Especially worrisome is the abundance of microplastic pollution of soil and water resources as plastics break down, enabling the transmission of pathogens up the marine and terrestrial food web and eventually to humans (Das et al., 2019). Various responses to deal with this pollution include country-wide bans on single-use plastic (such as Taiwan), not accepting any more foreign waste imports, and beach cleanups to remove larger plastic waste from the shoreline. (Rajmohan et al., 2019).

Electronic waste (abbreviated as e-waste) has been exponentially increasing due to the rapid increase and spread of technological progress, making existing technologies obsolete faster, and the waste is estimated to increase to 50 million metric tons in 2018. This proportion of waste is composed of various discarded and at end-of-life products including computers, consumer electronics, mobile phones, and large appliances. Although e-waste contain elements of high demand that could be recycled, such as rare earth elements and other precious metals, some plastics, and the glass, improvements in design for these electronics have hampered the ability to safely and easily separate these portions from the overall products, and the necessary infrastructure built for waste management of this resource (collection, recycling, and disposal) has not been developed. Instead, the majority of e-waste of developed countries is shipped to developing countries with more lax environmental regulation and thrown into landfills. Barriers to recycling include economies of scale and lack of collection infrastructure to extract minor concentrations of elements, lack of financial incentives, lack of governing policy, a large assortment of products, and the technical difficulty of separating recyclable material from the product. Possible solutions include extended producer responsibility (EPR) laws compelling the manufacturer to be responsible for collection, disassembly, and recycling of its products, giving incentive to change design standards toward this end. Other acceptable methods include recycling taxes paid by consumers or turning in past electronic waste such as old cell phones in exchange for newer ones (Tansel, 2017).

Responses to Limit Waste

One approach to limit waste while still maintaining consumption would be to implement innovation into design thinking and within human processes. Examples include supply chains which follow a circular economy, a process which restores technical materials and regenerates biological materials in the hope of a zero-waste economy. As opposed to the linear model of production, emphasizing one-time use and disposal, or even a closed loop supply chain, the circular supply chain reduces waste production through working with other industries to utilize different materials to have longer end-to-life. Successful models of circular supply chains include food cooking oil waste to be transported and turned into an energy source, or textile products being recycled for insulation in the construction industry. Distinct parts of this circular economy to reduce waste management include *repurposing* used materials for a different use (such as old desktop computers to be repurposed as thin computers), *refurbishing* old materials to restore their function, *remanufacturing* past products to a similar but non-identical new product, and traditional *recycling.* This thinking not only applies to production but also to supply chains and logistics, as reverse logistics can view secondary markets as ends of waste material *(*Farooque et al*., 2019).* As opposed to "cradle-to-grave" or the 3 R's, engineers and designers hope to offer multiple generation lifecycles for the same product, expanding the 3 R's to the 6 R's, adding *Recover, Redesign,* and *Remanufacture*. Current environmental and economic thinking only considers one lifecycle for a product, hardly ever rigorously analyzing effects on the 6 R's to all products. To achieve this new line of thinking, design for one particular end goal — whether that be designing for environment, disassembly, modularity, or maintainability — is not enough; rather, the proposed product should be designed according to multiple strategies to enhance the possibility of the product being used for another generation lifetime. This is not merely theoretical; Xerox offers up 7 different revenue streams for the same product and plans to unveil a photocopier with three lifecycle generations, while BMW has integrated recycling parts by color coding for three decades to someday produce cars out of 100% recycled parts (Go et al., 2015).

Policy measures have been enacted to limit the production of waste as well as to improve waste management practices. Taiwan is moving to ban all single-use plastic, including cups, bags, and silverware, by 2030 and has already banned plastic straws, while the EU has implemented rules to collect more than 50-65% of generated waste and recycle 25-45% of packing waste. Indian policy must implement pre-existing laws to build adequate local waste collection infrastructure and new landfill sites (Rajmohan et al., 2019). Extended producer responsibility laws force producers to provide for the collection and recycling of e-waste services, but clear regulation is needed for designers to implement recyclable methods of design, such as easier product disassembly and reuse (Tansel, 2017). Yet, policy prescriptions should not be merely transplanted to other areas without proper knowledge and context of their waste infrastructure system. For instance, while developing countries have a higher percentage of organic waste in their waste stream, suggesting composting as the preferred option due to low cost and high organic content (Das et al., 2019), this solution is not achievable in the waste stream of Latin America and the Caribbean because the waste stream is not separated by constituent; all of the different waste components are jumbled together, threatening to contaminate any compost product (Margallo et al., 2019). Policy options such as increasing recycling of waste material will have no appreciable effect if the specific country lacks the access to the proper infrastructure; for instance, recycling policy efforts may seem futile for Latin America and the Caribbean, which has a 2.2% formal recycling rate, while legislation such as changing practices of waste collection in open dumpsters to formal landfills would seem more beneficial for their particular situation (Margallo et al., 2019). Finally, the evidence used to prescribe effective policy may be lacking; there is no lifecycle assessment for marine plastic pollution (Rajmohan et al., 2019) nor for most developing countries, requiring the use of lifecycle assessments that are only partially comparable to the specific countries in question (Margallo et al., 2019).

Ultimately, the reduction of waste is most effectively driven by the change of consumer values away from consumption and toward sustainability. In this view, traditionally endorsed consumer values of convenience and acquisition are exchanged for patience and contentment in the sense of not feeling the need to buy unnecessary goods. With this transformation in individual values, this will lead to a societal change where consumers are pushed toward these other values by their peers (Sayre, 2010). This societal change is feasible; my own generation has seen a push against single-use bottled water; the change in culture shames people for not using reusable water bottles. This change in consumer values will lead to a greater awareness of consumer responsibility against further waste increases. From greater recycling of plastics and e-waste (Rajmohan et al., 2019) to a faster transition in industry to the circular economy in production and supply chain management (Farroque et al., 2019) to the facilitation of more efficient waste management strategies (Das et al., 2019), all of these are driven by greater consumer environmental awareness through a change in consumer values.

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