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The Deficiencies in Research and Development of Plastic Pollution Prevention Technologies

Fangyu Li

Peddie School, Hightstown, NJ, USA

You are navigating around the Pacific Ocean, enjoying the vast deserted blueness. Just as you were about to dose off, you are shocked by the sight of a tremendous patch of white, stretching all the way to the skyline. Upon getting closer, you realize that this is an enormous pile of garbage – plastic garbage – floating in the middle of the ocean. This is the Great Pacific Garbage Patch, containing 1.8 trillion pieces of plastic, spanning an area of 1.6 million square kilometers, equivalent to three times the size of France (The Ocean Cleanup). And yet, the Great Pacific Garbage Patch is only a small part of the enormous volume of plastic currently circulating in the world's oceans.

Plastic pollution is an increasing threat to our world. In 2016, there was an estimated 150 million metric tons – equivalent to the weight of 186 Golden Gate Bridges – of plastic garbage in the marine environment (World Economic Forum, 2016). More than 14 million tons of plastic garbage ends up in the ocean every year (IUCN). By some estimates, this rate will double by 2040 (National Geographic). This is catastrophic for the entire world as plastics in the ocean would cause significant numbers of deaths in marine animals due to entanglement by plastics or even eating plastic. It is estimated that plastic pollution kills over 100,000 marine animals each year, 81 out of 123 marine mammal species are known to have eaten or been entangled in plastic, and all seven sea turtle species are affected (World Wildlife Foundation). Plastic pollution also pose direct threats to mankind as degraded microplastic particles enter the food chain and even the atmosphere (Allen et al.).

As the urgency of this problem increases, researchers are devoting more attention to technological solutions for combating it. However, this research and associated technological developments have failed to produce satisfactory results. One observes this in steadily increasing ocean plastic content and plastic inflow rates. Many factors are responsible for the persistence of the plastic pollution issue, such as insufficient government regulations (Testa et al.) and profit-motivated resistance to clean transitions on the part of companies (Rogers et al.; Meredith). However, this opinion paper is going to focus on several in particular: 1) insufficient analysis aimed at explaining the success or failure of existing products. 2) little cooperation between the NGOs and companies doing this research, and between these organizations and government. 3) a lack of category-spanning research and analysis concerning plastic pollution prevention technologies. All of these factors are pivotal for productive future technological development, especially when it comes to technologies.

Current plastic pollution technologies can be classified into two categories: biochemical and robotics. Within the robotics class, there are two different product varieties: plastic collection, plastic monitoring and processing, and X. Plastic collection technologies largely consist of algorithmically programmed robots collecting garbage in the ocean. An example is Ocean Cleanup's System 002, which is an "Artificial Coastline created where there are none, to concentrate the plastic" – comprised by two unmanned ships powered by an algorithm that recognizes plastic hotspots and a long, U-shaped retention zone to guide the plastic into a collection area (The Ocean Cleanup, Itkan). There are also products like WasteShark and BluePhin, which are both small, autonomous robots that primarily work around piers and marinas (Swan; WasteShark; De Leon). The plastic monitoring and processing technology category is older and more developed. Example products include Hyperspectral Imaging Technology, which can efficiently detect microplastic contamination in soils (Shan et al) and allows researchers to sense, image, and monitor the distribution of large ocean garbage patches (Garaba et al).

Yet with all this technological development, why hasn't the ocean plastic pollution situation improved?

One of the primary reasons is a lack of analysis concerning the successes and failures of each product. Currently, most research effort concentrates on developing new products, with less attention to implementation. Both of the technology types discussed above have flaws that must be dealt with in order to have a significant impact on the problem. For instance, the plastic collection technologies are simply too small. System 002 is perhaps the only large-scale technology of its kind available. Its peer products are largely small-scale robots and bins built to collect and skim small amounts of plastics and pollutants. (Swan; De Leon; Seabin)

Governments are granting little attention and resources to this field. All of the products mentioned above have been developed by NGOs and young startups, and these NGOs and businesses are doing most of their R&D in isolation.

This lack of coordination and collaboration leads to another problem: great overlap in ongoing research, which is leaving gaping holes. For example, most of the technologies and products under development and in use focus on *macro*-plastic prevention and collections. The same goes for research; very little focuses on *micro*-plastic pollution. Current microplastic prevention technologies are mainly focused on residential solutions such as "Cora Balls"—balls placed in laundry machines to capture microplastics from clothing (Schmaltz et al). If microplastic prevention technologies stop at these residential levels and researchers over-emphasize macro-plastic prevention technologies, we would be missing an important piece of the puzzle, since macro-plastics break down into microplastics (Schmaltz et al).

On the other hand, if organizations and companies collaborate, capitalizing on and sharing their strengths, and with the right amount of governmental support, these organizations could soon scale up their local solutions. For example, BluePhin is currently only operating in Dubai, WasteShark is currently in a few marinas in the Netherlands, Dubai, and the UK. With governmental collaborations and assistance, they are sure to bring their solutions into numerous different parts of the world. Collaborations between themselves and governments can also maximize current resources and technologies of these companies and devise a much more effective and prevalent solution in face of this global threat (Schmaltz et al).

Not only are there not enough cooperations between NGOs and companies developing the same category of technologies, but there is also a severe lack of category-spanning research and analysis of these technologies. This is pivotal for taking a more effective approach in the battle against plastic pollution. There are numerous companies developing technologies of plastic monitoring and tracking such as hyperspectral imaging as aforementioned (Garaba et al. Shen et al.) and various plastic tracing apps. As seen in the one developed by the Norwegian University of Science and Technology that not only "recognizes plastic from an image", but also "makes it much more convenient and efficient for the tracking and analyzing the sources of plastic pollution, allowing cleanup projects to be more targeted" (Norwegian University of Science and Technology). There are also other processing technologies such as the Urban Rig implemented by the Japanese government to decompose waste, and recover oil, charcoal and metals for recycling from untreated marine debris. (Public Relations Office).

With this abundance of research already existing in tracking and monitoring the distribution of plastics, we still see NGOs and companies in the plastic collection industry developing algorithms independently to power their own collection tools, the algorithms they are developing focus on identifying plastic hotspots, analyzing distribution of plastic in marinas and garbage patches and guiding robots and ships to collect them. Those are exactly what the apps and algorithms developed by companies in the plastic monitoring industry excel at. Developing new algorithms is not only unnecessary work, but it also leads to the lack of implementation of appropriate systems for monitoring and sampling as everyone's still just working on their own. Companies and NGOs working on plastic collection could potentially benefit tremendously from the algorithm and data being developed and collected by the plastic monitoring and tracking industry as it would make it much easier for the collection process. This cooperation and sharing of data are potentially a huge benefit to both sides of the story, plastic collection companies can produce more advanced and effective machines with the abundance of data and more mature algorithms, while the monitoring companies will be able to have an additional data source and cover a much larger area. However, only a few product descriptions mentioned potential collaborations with plastic collection technologies. Therefore, we can see clearly that there already exist a solid foundation to work on in terms of the technologies being researched to counter the threat of plastic pollution. All the categories have already had in-depth research, but this lack of communication and cooperation between the categories is one of the biggest reasons why so few progress had been made.

Plastic pollution is a global threat that threatens all organisms on earth, including mankind. In order to effectively counter this hazard, organizations must act together. Both inter and intra-industry collaboration will be essential, as will government support. Together, we can achieve more effective plastic pollution solutions, and a brighter future for all.

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