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Challenges to Solving the Problem of Plastic Waste

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ABSTRACT

Plastic waste collecting in the Pacific Ocean is a threat to all nations of the Pacific Rim. Environmentalists estimate that an island of plastic in the Pacific is larger than the land area of Texas, and may be better described as a "continent" rather than an island. The problem is a concern for East Asian nations as well as for the United States. Limiting or banning the use of plastics is not practical or feasible because the use of plastic is woven into our daily habits; plastic is inexpensive, and alternatives have their own environmental consequences. Conventional wisdom advocates for recycling, but for a variety of reasons recycling alone is inadequate to address the growing problem. The reality of recycling is that plastic cannot be 100% recovered; a further reality is that current recycling procedures are inefficient. Financial incentives to greatly improve the recovery of plastic waste must be part of the solution. We must explore new technologies that are capable of decomposing plastics into its original petroleum base for use as fuel to power automotive and aviation transportation, and the myriad other products also made from petrochemicals. With advances in the technology of biodegrading plastic, we can replace crude oil that we currently extract from the ground, with material created from plastic waste. These technologies hold the promise to address several environmental, social, and political problems simultaneously.

Keywords: Recycling plastic; Biodegrading plastic; Converting plastic waste to petroleum.

INTRODUCTION

Plastic waste collecting in the Pacific Ocean is a threat to all nations of the Pacific Rim. Rivers and streams are clogged with plastic waste. Harbors in East Asia contain so much plastic debris that they resemble garbage dumps. CNN Business asserts that presently the Pacific Ocean contains more plastic than fish. [1]

The fish we do have are eating plastic pollution. The plastic breaks down to tiny particles, which is ingested by fish. This is disastrous for that huge segment of the world's population that feeds itself from the sea. [2]

Conventional wisdom proposes solving the problem of accumulating plastic waste by 1) recycling; 2) limiting use of plastics; 3) outlawing mixed plastic--reducing the varieties of different types of plastic so that they can be sorted into homogenous material that can be efficiently, effectively, and economically recycled, and 4) outlawing popular single-use plastic, like plastic product packaging, utensils, bags, or straws.

Promising work is being done to transform plastic back to its original form--petroleum. If we could make petroleum out of waste plastic, we could find a new source for fuel, as well as a source for manufacturing all of the products made from petroleum.

A river clogged with plastic waste flows through Manila.

CONVENTIONAL SOLUTIONS ARE NOT WORKING

Reducing the amount of plastic we use does not work

Disposable plastic is too much a part of all of our every-day lives. People and businesses like using plastic because it is cheap, versatile, and durable. [3]

Limitations imposed by governments—laws and regulations—meet with resistance because use of plastic is woven into our culture

Government action to limit the use of plastic has been ineffective. Many jurisdictions have tried to limit the use of plastic bags through laws and regulations. California is trying to eliminate single-use plastic straws. The problem with measures of this sort is that plastic straws and bags are popular, so the limitations are met with considerable public resistance.

An issue larger than public resistance to using less products made from plastic is that governments are pressured by lobbyists for the petrochemical industry not to take measures that would reduce the amount of plastic used by the public. At a recent meeting of the G20[1] in Japan this past July, the group discussed limiting the manufacture and use of plastic. However, rather than limit production and use, the G20 leaders announced that they would need to find other solutions to fix this problem. Noting the "important role of plastics in society." The world leaders made no commitment to curb the production of new, single-use plastic. [4]

The only solution that the G20 discussed during their meeting was to encourage people to take voluntary actions in compliance with the national policies, which is an ineffective solution that will not significantly impact the plastic waste problem. [5] The biggest stumbling block to the G-20 nations agreeing to limit production of plastic, was opposition by the United States, the

[1] The **G20** (or **Group of Twenty**) is an international forum for the governments and central bank governors from 19 countries and the European Union (EU). Founded in 1999 with the aim to discuss policy pertaining to the promotion of international financial stability, it seeks to address issues that go beyond the responsibilities of any one government. Collectively, the G20 economies account for around 90% of the gross world product (GWP) and 80% of world trade. Gilpin, Robert (2001). *Global Political Economy: Understanding the International Economic Order*. Princeton, New Jersey: Princeton University Press.

world's largest producer of single-use plastic. The U.S. simply refuses to accept the global objectives of the majority of G20 nations. The biggest plastic waste exporters refused to accept setting a global objective to reduce the production of single-use plastic. [5]

The narrative pushed by the G20--that consumers need to recycle, and that will solve the problem--is a fallacy. In his article, "Banning Plastic Bags Is Great for the World, Right? Not So Fast," [6] Ben Adler, discusses how laws and regulations in various jurisdictions have not been successful in limiting the amount of plastic waste: New York City imposed a 5-cent-per-bag fee on single-use bags handed out by most retailers; Massachusetts has attempted to ban plastic bags from being dispensed by many retail businesses and require a charge of 10 cents or more for recycled paper or reusable bags, and 32 Massachusetts municipalities have passed bag bans or fees; In California, at least 88 localities, including Los Angeles and San Francisco, plus cities and towns in more than a dozen other states and more than a dozen other countries, have also passed bans or fees on plastic bags. But, as Adler points out, these regulations have been ineffective in reducing the amount of plastic waste that is accumulating. Adler argues that, for a number of reasons, it makes no sense to continue to manufacture, and promote single-use plastic that adds to the enormous quantity of waste plastic, without a rational plan to deal with the problem at its source. [6]

Matt Wilkins, a postdoctoral researcher at Vanderbilt University's Center for Science Outreach, and a self-described "ecologist and evolutionary biologist," published an article in *Scientific America* that reviews the attempts made by governmental entities at the local, state, and federal levels going back to the 1950s to stem the flood of plastic waste that befouls the environment. [7] He points out that, for a variety of reasons, government action, whether to foster recycling, or limit the use of plastic, has not worked. Wilkins terms it "a lie" that "blame for the plastic problem [should be placed on] wasteful consumers and that changing our individual habits will fix it."

Wilkins argues that the attempt by individuals to fight the problem of plastic waste ruining the environment by recycling is "wholly inadequate" and "distracts from the real problem," which is that single-use plastic is the problem. "It's a lie," Wilkins contends, "that wasteful consumers cause the problem and that changing our individual habits can fix it." Plastic bags can persist in the environment for half a millennium—is an incredibly reckless abuse of technology. Encouraging individuals to recycle more will never solve the problem of a massive production of single-use plastic that should have been avoided in the first place.

Wilkins continues, "Scientists have long recognized that plastics biodegrade slowly, if at all, and pose multiple threats to wildlife through entanglement and consumption." Starting in the 1950s, corporate users of plastic, like Coca-Cola, Anheuser-Busch, Phillip Morris and others, formed a non-profit called Keep America Beautiful, which among other efforts, produced Public Service Announcements that shamed "litterbugs," a term the movement invented. [7]

At face value, these efforts seem benevolent, but they obscure the real problem, which is the role that corporate polluters play in the plastic problem. This clever misdirection has led journalist and author Heather Rogers to describe Keep America Beautiful as the first corporate greenwashing front, as it has helped shift the public focus to consumer recycling behavior and actively thwarted legislation that would increase extended producer responsibility for waste management.

Banning plastic bags and straws will not solve the problem

The movement to ban plastic bags, initiated by local and state government in the United States, actually increased the plastic consumption due to a phenomenon called "leakage." According to Rebecca Stropoli, when stores stopped giving free plastic bags to their customers, people started to buy plastic bag instead due to the exceptional usefulness of plastic bags in our daily lives. In a study conducted by Stropoli, she found that the plastic bag ban policy reduced the use of plastic shopping bags by about 40 million pounds per year, suggesting that the policy was actually working. However, she also found out that the purchase of trash bags, as a replacement for plastic shopping bags, increased by about 12 million pounds per year. This suggests that the reduction of plastic bags by the policy was counterbalanced by the increased usage of plastic trash bags, showing how the government regulation/policy on the plastic bags is not an effective way to control the proliferation of plastic waste. [8] [9]

As early as 1953, Vermont passed a law which banned the sale of beverages in non-refillable containers. Single-use packaging was just being developed, and society was at the crossroads of reusable containers being replaced by disposable, single-use plastic bottles and aluminum cans. The very corporations that had founded Keep America Beautiful were so successful in thwarting laws that would have protected the environment that Vermont allowed its law to expire four years after it was enacted; the single-use container industry expanded, unfettered, for almost 20 years.

Ben Adler points out that the adverse impacts of plastic bags are undeniable: They pile up in landfills, block storm drains, litter streets, get stuck in trees, and contaminate oceans, where fish, seabirds, and other marine animals eat them or get tangled up in them. As longtime plastic bag adversary Ian Frazier recently reported in *The New Yorker*, "In 2014, plastic grocery bags were the seventh most common item collected during the Ocean Conservancy's International Coastal Cleanup, behind smaller debris such as cigarette butts, plastic straws, and bottle caps." The New York City Sanitation Department collects more than 1,700 tons of single-use carry-out bags every week, and has to spend $12.5 million a year to dispose of them. [6]

Bag bans have had some limited success in cutting this litter off at the source: In San Jose, California, a plastic bag ban led to an 89 percent reduction in the number of plastic bags winding up in the city's storm drains. Fees have a smaller, but still significant, effect. Washington, DC's government estimates that its 5-cent bag tax has led to a 60 percent reduction in the number of these bags being used, although that figure is contested by other sources.

Alternatives to plastic bags are not the solution

But is the alternative--paper bags--better for the environment? No.

"People look at [paper] and say it's degradable, therefore it's much better for the environment, but it's not in terms of climate change impact," says David Tyler, a professor of chemistry at the University of Oregon who has examined the research on the environmental impact of bag use. The reasons for paper's higher carbon footprint are complex, but can mostly be understood as stemming from the fact that paper bags are much thicker than plastic bags. "Very broadly, carbon footprints are proportional to mass of an object," says Tyler. For example, because paper bags take up so much more space, more trucks are needed to ship paper bags to a store than to ship plastic bags.

Still, many environmentalists argue that plastic is worse than paper. Climate change, they say, isn't the only form of environmental degradation to worry about. "Paper does have its own

environmental consequences in terms of how much energy it takes to generate," acknowledges Emily Norton, director of the Massachusetts Sierra Club. "The big difference is that paper does biodegrade eventually. Plastic is a toxin that stays in the environment, marine animals ingest it, and it enters their bodies and then ours."

The Australian study concluded that the best option appears to be a reusable bag, but one made from recycled plastic, not cotton. "A substantial shift to more durable bags would deliver environmental gains through reductions in greenhouse gases, energy and water use, resource depletion and litter," the study concluded. "The shift from one single-use bag to another single-use bag may improve one environmental outcome, but be offset by another environmental impact."

The ideal city bag policy would probably involve charging for paper and plastic single-use bags, as New York City has decided to do, while giving out reusable recycled-plastic bags to those who need them, especially to low-income communities and seniors. (The crunchy rich should already have more than enough tote bags from PBS and Whole Foods.)

The larger takeaway is that no bag is free of environmental impact, whether that's contributing to climate change, ocean pollution, water scarcity, or pesticide use. The instinct to favor reusable bags springs from an understandable urge to reduce our chronic overconsumption, but the bags we use are not the big problem.

Recycling is not the answer

Ninety-one percent of all plastic is not recycled. [10]

Even if we could recover 100% of plastic waste through recycling--the current figure is less than 10%--we would have to face the reality that current technology has no ability to deal with the mountains of accumulating recycled plastic.

Among the many obstacles that render recycling impractical--that is, even if we could encourage the public to recycle at a rate that would have a salutary effect on the environment--is that "mixed plastic" cannot be managed with a single process. Different types of plastic melt at different temperatures; bacteria that degrades and decomposes one type of plastic, has no effect on other types of plastic.

Another obstacle is that the recycling of plastic is also managed locally, rather than the central government. What each council decides to recycle depends on the resources available. For example, in Greater Manchester in the UK, the only plastic recycled is plastic bottles because they don't have the technology available to sort between different types. [10]

PROMISING IDEAS FOR REMOVING PLASTIC FROM THE ENVIRONMENT

Assuming we can solve the problems that currently render recycling inefficient and ineffective, we do have ideas about how to incentivize the collecting of waste plastic that currently clogs our rivers and oceans.

We have promising ideas about how to remove plastic waste from the ocean--witness the work being done by The Ocean Clean Up project--and promising ideas about how to incentivize entrepreneurs to collect plastic waste--witness The Plastics Bank, but we have to focus on what to do with the plastic that is recovered.

The "Ocean Clean Up" project

The Ocean Clean Up is an organization founded in 2013 by an 18-year-old Dutch inventor, Boyan Slat. Today, the organization, headquartered in Rotterdam, the Netherlands, employs more than 80 engineers, researchers, scientists, and computational modelers working to rid the world's oceans of plastic. [11]

The organization has created a "boom"—a large net that is capable of sweeping large swaths of ocean to remove floating plastic debris that fouls the water.

On its website, Ocean Clean Up has posted a review of the literature relating to large patches of plastic debris floating in the oceans. The web posting identifies the dangers posed by the patches of plastic garbage. According to the information provided by the website:

- "The Great Pacific Garbage Patch (GPGP) is the largest of the five offshore plastic accumulation zones in the world's oceans. It is located halfway between Hawaii and California."
- "At the time of sampling, there were more than 1.8 trillion pieces of plastic in the patch that weigh an estimated 80,000 tonnes. These figures are much higher than previous calculations."
- "A total of 1.8 trillion plastic pieces were estimated to be floating in the patch – a plastic count that is equivalent to 250 pieces of debris for every human in the world."
- "Because the plastics have been shown to persist in this region, they will likely break down into smaller plastics while floating in the GPGP. Once they become this small, microplastics are very difficult to remove and are often mistaken for food by marine animals."
- "Studies have shown that about 700 species have encountered marine debris, and 92% of these interactions are with plastic. 17% of the species affected by plastic are on the IUCN (International Union for Conservation of Nature) Red List of Threatened Species."
- "Floating at the surface of the Great Pacific Garbage Patch (GPGP) is 180x more plastic than marine life. Animals migrating through or inhabiting this area are then likely consuming plastic in the patch."
- "Through a process called bioaccumulation, chemicals in plastics will enter the body of the animal feeding on the plastic, and as the feeder becomes prey, the chemicals will pass to the predator – making their way up the food web that includes humans. These chemicals that affected the plastic feeders could then be present within the human as well."
- "The United Nations reported that the approximate environmental damage caused by plastic to marine ecosystems represents 13 billion USD. This figure included the cost of beach cleanups and the financial loss incurred by fisheries"
- At least 690 species have encountered marine debris.
- At least 17% of impacted species listed on the IUCN Red List as near threatened or above.
- 92% of the individual encounters with marine debris related to encounters with plastic.
- At least 10% of the species encountering marine debris had ingested microplastics.

According to Ocean Clean Up, a total of 340 original publications were identified documenting encounters between marine debris and marine organisms. These reported encounters total 693 species. 76.5% of all reports listed plastic amongst the debris types encountered by organisms making it the most commonly reported debris type. 92% of all encounters between individual organisms and debris were with plastic.

Consequences of encounters were considered where documented, suggesting that direct harm or death (defined as where the individual was reported to have been injured or killed as a direct result of the encounter with marine debris) is a more common consequence of entanglement than ingestion, with 79% of cases resulting in direct harm or death for cases of entanglement compared to 4% of cases of ingestion

All known species of sea turtle, 54% of all species of marine mammal, and 56% of all species of seabird were affected by entanglement in or ingestion of marine debris and the percentage of encounters has increased for all taxonomic groups. While the number of reports of species of fish encountering marine debris remains low (0.68%), the number of species affected has almost doubled since 1997.

As promising as is the work of Ocean Clean Up, we still have to figure out what to do with the plastic debris that is collected.

The "Plastic Bank"

The Plastic Bank is a new way to minimize ocean plastic waste, especially in "disenfranchised communities," by using plastic as currency to trade for daily-life products such as shampoo, cooking fuels, and wifi. People in those communities gather plastic waste and trade with the recycling center, where the plastic is then sold to big companies and corporations who need plastic. The concept of a "bank" gives people a sense of the value of plastic, which is one of the reasons why it works. Gradually, more people will find value in plastic by collecting and then using it like currency. This has the potential to significantly reduce both poverty and plastic waste--a win-win.

The bank accepts raw waste plastic from its "depositors" and delivers it to recyclers who can transform the waste into a commodity with value. The citizen-collectors are incentivized to gather waste because they can "withdraw" the "money" deposited for items useful in their every-day day lives. They can also exchange the assets on deposit for both actual and digital money. Thus, collecting waste-plastic becomes employment in which local people of the communities can earn stable income. The bank is able to exchange plastic waste for money and other goods because they recycle the waste plastic into usable plastic--so-called "social plastic" as differentiated from "waste plastic" --to sell to their partner-companies, which is how they generate revenue.

Some of the well-known bank-partners are Evian, Seinz, Aldi and Henkel. These companies also manufacture social plastic products that they sell, promoting the value of plastic waste and incentivizing its collection.

Plastic Banks hold the promise of incentivizing small-scale fishermen--or anyone with a boat—to contribute to cleaning the oceans and improving our global environment.

VIABLE LONG-TERM SOLUTIONS

Even if we could intercept plastic before it enters the waste stream through recycling, or capture and remove it from the environment through projects like Ocean Clean Up or the Plastic Bank, we would have to confront the problem that mixed plastic cannot be repurposed. We would still have to deal with the mountains of collected waste plastic.

Best Long term solutions:

A. Biodegrading plastic waste
B. Processing plastic so that it is returned to its original petrochemical state--making petroleum products such as fuel and plastic out of processed recovered plastic

DISCUSSION OF Biodegrading Plastic

A. One solution to the environmental problem of plastic is to utilize certain bacterium that could possibly degrade plastic wastes. The researchers have determined bacterium Bacillus sp. ITP.10.2.1 as the bacterium that has the capability of degrading synthetic plastic. From the research, the researchers have shown that "this bacterium has the potential to be further developed as a commercially synthetic plastic degrading bacteria in industrial rank", which is important to notice because it shows that the progress is going on and that by doing more research on this bacterium and by continuing this progress, we would be able to degrade the mass production of synthetic plastic in the future. In addition, their experiment of using Bacillus sp. ITP 10.2.1 to biodegrade PET plastics produced results that showed the potential of this bacterium. After comparing the initial weight and the weight after four weeks of the PET plastic films, they have determined that the average weight reduction of those plastic films were 4.77% byte to byte with the margin of error of 1.461%, which shows the significance of this bacterium. This experiment was observed by Scanning Electron Microscopy (SEM) and they figured it out that bacterium Bacillus sp. ITP.10.2.1 caused "erosion and damage to the surface of the tested polyethylene terephthalate plastic film", showing the potential to be utilized for reducing the amount of plastic waste in our world.[2] [3]

THIS IS PROMISING RESEARCH THAT NEEDS TO BE PURSUED AND DEVELOPED

B. What we now have to do is put research funding into studies that will find the bacteria that will biodegrade other types of plastic

DISCUSSING THE SECOND PROMISING TECHNOLOGY FOR DEALING WITH THE MOUNTAINS OF RECYCLED AND RECOVERED PLASTIC WASTE:

Returning recovered plastic waste to crude petroleum such that it is usable for fuel or all other products made from crude petroleum

I HAVE THE TECHNICAL SPECIFICATIONS FOR HOW THIS IS ACCOMPLISHED, BUT I AM GOING TO SKIP THE SPECIFICS OF THE PROCESS, BECAUSE IT IS HARD TO FOLLOW AND UNDERSTAND.

BUT THE POINT IS THAT The progress made in degrading municipal plastic waste into fuel. At present, the petrochemicals produced are not usable because they have contaminates that will cause pollution when burned.

HE POINT IS: progress is being made degrading municipal plastic into fuel, but the research is on-going, and is not yet ready to be put into practice. It is promising for the future--that scientists will overcome the current problem OF ACCUMULATING PLASTIC WASTE.

SKIP THIS. GO TO CONCLUSION, BELOW:

The thermal degradation of different municipal plastic wastes containing polyethylene, polypropylene, ethylene-propylene copolymer, polystyrene, polyamide and polyurethane rubber was investigated in a horizontal tube reactor using different cracking parameters. The further utilization of volatile products, i.e. fuel-like utilization was investigated; moreover, the

[2] http://repo.unand.ac.id/25124/1/Jurnal%20international%20IRJP.pdf

[3] **http://ctplastics.wpengine.com/resources/connecticut-plastics-learning-center/biodegradable-plastics/**

effects of the cracking parameters (temperature, residence time) on the yields and properties of products were determined.

- It was found that the chemical structure of polymers greatly affected the qualitative and quantitative properties of volatile products. The yields of volatile products increased both with temperature and residence time. The yields of liquids of 10–25% separated from the gases leaving the reactor could be increased further by 10–15% by distilling the residue. When polystyrene was also in the polymer blend, a significant aromatic content was observed, mainly ethyl-benzene, styrene, toluene and benzene. After distillation, the aromatic content was concentrated mostly in the lighter fractions (F1), which is an advantageous property for further fuel-like utilization. Similar to the aromatic content, the heteroatom content of product liquids was also influenced by the structure of the raw material. Cracking the MPW-2 sample yielded a liquid with high sulphur and nitrogen content. This is a disadvantageous property for further utilization. It was found that the liquids had approximately 50% olefin content depending on cracking parameters.[4]

CONCLUSION

The future of life on this planet depends upon us finding a solution to the exponentially increasing amount of plastic waste that is clogging our rivers and streams. While it would be nice to think we could solve the problem by limiting the amount of disposable plastic we use, or recovering what we do use through recycling, unless we can figure out what to do with the mountains of recovered plastic, we will just be moving plastic from one place to another for storage, with no end in sight. Our best and only hope is to find a way to transform plastic waste, either by bio-degrading it or returning it to the petroleum from which it was originally manufactured.

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