

Single-Use Plastics and Their Effects on the Environment

Ivy Walbert — June, 2020

Plastics are everywhere. We eat and drink out of them, wear them, package things in them. Many plastics are intended for only one use, after which they are often immediately thrown in a landfill. In fact, 40 percent of all manufactured plastic is used for packaging and intended for a single use.¹ Plastics of all kinds, specifically these single-use plastics, have been the topic of environmental discussion for years, due to the many serious and harmful effects they can have on the environment.

In this paper I will discuss how plastic is made and the negative effects it can have on the environment, look at several common types of single-use plastic and the possible alternatives to them, and finally discuss possibilities for legal policies to help reduce our use of single-use plastics.

About Plastics

Plastic is a synthetic material made from organic polymers, materials made of long repeating molecular chains, such as polyethylene, PVC, or nylon, that can be molded into various shapes while soft and then set into a hard or slightly elastic form. When these polymers are in the form of long chains, like beads on a string, they form thermoplastics, which comprise 92 percent of all plastics. These can be melted and rehardened. When the polymers are in two or three dimensional networks, they create thermoset plastic, which, once hardened and set, cannot be melted and reshaped. The vast majority of plastics are synthetic plastics, meaning they are made from crude oil, natural gas, or coal. Most plastics are carbon based, although some, called silicones, are silicon based.

Plastics are an environmental problem for several reasons. One of the largest of these problems, particularly for single-use plastic, is waste and pollution. Plastic bottles, bags, straws, and other plastic waste from landfills can end up in large masses in the ocean, where they can be mistaken for food and harm marine wildlife.² Unlike paper, wood, or other natural materials, plastic is not biodegradable. This means that rather than easily decomposing, plastic can stick around for hundreds of years, and will eventually just break up into smaller and smaller pieces.³ The smallest of these pieces, specifically 5mm and

¹ Laura Parker, "[Fast facts about plastic pollution](#)," National Geographic, December 20, 2018

² "[Ocean Plastics Pollution](#)," Center for Biological Diversity

³ Erica Cirino, "[Plastic: The big breakup](#)," National Geographic Society Newsroom, April 29, 2016

under in size, are called microplastics. These microplastics from our plastic waste are polluting bodies of water, have been making their way through marine food chains, and have even been found in shellfish for human consumption. One significant form of microplastic pollution that is less well known is synthetic fibers from clothing. These fibers, which are made of plastic, are released into the water each time they are washed, adding to the growing problem of microplastics in our environment.⁴

There are also environmental issues with the manufacturing of plastics. The process of making plastic releases many gasses into the atmosphere, some of which are toxic, such as trichloroethane, toluene, methylene chloride, and many more. These chemicals can cause respiratory depression, seizures, nausea and vomiting, serious heart problems such as cardiac dysrhythmia, and many other symptoms. These side effects are especially prominent and serious among people who are involved in the manufacturing of plastics.⁵

There are also some concerns about the health risks of plastic, the most common being about BPA, which has been used in some plastics and resins since the 1960s. One study found that in a sample group of people between the ages of 17 and 19, roughly 86 percent of them had BPA in their bodies, even after following strict rules to avoid BPA for a week. There are also concerns that BPA is linked to cancer, hormone imbalances, and negative effects on reproductive health.⁶

Case Studies

Plastics intended for a single use are everywhere, and most things are packaged in them, from food, to clothing, to cleaning supplies. I will be looking into 5 different examples of single-use plastic, the issues with them, and some possible alternatives.

Plastic bags

Arguably the most commonly discussed form of single-use plastic is plastic grocery bags. Americans use 100 million plastic bags per year, more than 300 bags per person per year, which require 12 million barrels of oil to produce. The lifespan of these bags is up to 1,000 years, and even after they do degrade they don't fully break down, but instead become microplastics that continue to harm the environment.⁷

⁴ Brian Resnick, "[Ocean plastic pollution: why our clothes are part of the problem](#)," vox.com, January 11, 2019

⁵ "[PTF: ENVIRONMENTAL IMPACTS](#)," ecologycenter.org

⁶ While these concerns are widespread and mentioned in many articles, I couldn't find the original studies.

⁷ "[Top Ten Facts about Plastic Bags in our Oceans](#)," environmentmassachusetts.org, and "[10 Facts About Single-use Plastic Bags](#)," Center for Biological Diversity

Three possible alternatives to single-use plastic grocery bags are

1. Paper grocery bags
2. Reusable bags, such as cotton ones
3. Universal recycling of plastic bags

I will examine the pros and cons of each of these three options.

According to the Canadian plastic industry, to match the environmental performance⁸ of a single-use plastic bag, you would need to reuse a paper bag three times, and paper bags are often not as durable as plastic ones.⁹ A 2007 study funded by plastic bag manufacturers in the United States found that paper bags take almost four times as much energy to make as plastic ones.¹⁰ Another concern that comes up about paper bags is their contribution to deforestation, but the practice of tree farming, which avoids clearcutting, has become more common, which helps to make this less of an issue.

Because of this, it seems that fabric bags would be the best choice. However, most fabric bags are made of cotton, and 25 percent of all pesticides used in the United States are used on cotton, giving conventionally grown cotton quite a large environmental cost. In fact, according to one estimate, for the environmental cost of a single-use plastic bag to equal that of a reusable cotton one, the cotton bag must be used about 131 times. If you use the bag each time you go shopping, 131 uses isn't all that difficult of a goal to achieve—assuming your bag was made well enough to last that long. If we assume you go shopping once every week, and you use your cotton bag each time, it would take about two and a half years to use it 131 times, so if you use a cotton bag you should make sure you choose one that is durable and well made.

An alternative is organic cotton. There are some farmers who grow cotton without any harsh chemicals or pesticides, meaning the fabric that comes from their farms has a much smaller environmental impact than conventionally grown cotton. According to the United States textile exchange, organic cotton also uses 62 less energy, produces significantly less CO₂, helps prevent soil erosion by using less fertilizer in soil, and uses 91 percent less water than conventionally grown cotton. However, organic cotton can be 20 to 30 percent more expensive for the consumer, and it is also worth noting that it produces a lower yield than conventional cotton. While it uses less pesticides and chemicals, the farmers must still

⁸ It is unclear what exactly is meant by “environmental performance.”

⁹ “[Paper Versus Plastic Bag Studies](#),” allaboutbags.ca

¹⁰ Patrick Barkham, “[Paper bags or plastic bags: which are best?](#),” The Guardian, September 20, 2011

contend with weeds, pests, and disease, and the alternative methods used to do that are generally more expensive than the chemicals used by conventional farmers, and can sometimes still be somewhat harmful. If you choose to buy cotton of any kind, I would recommend looking carefully at your sources.

Another relatively common “eco-friendly” option is bags made from bamboo. However, you must be careful when buying anything made from bamboo fabric, because often the fabric is not made directly from bamboo fiber but is actually rayon. Rayon is a man-made fiber created from the cellulose found in plant life, that may happen to be made from bamboo rather than another type of plant. This means it is an entirely different material than cloth made from bamboo fiber, which is not biodegradable, and the making of which can cause air pollution from the chemicals used.¹¹

Plastic bags can be recycled, but most general recycling companies do not take them. Many consumers may not know that most grocery stores accept grocery bags, and even if they do they must bring them to the store, making it a more time consuming process than using home recycling bins. Because of this, only about 1 percent of plastic bags in the U.S are actually returned for recycling. More importantly, plastic, unlike glass or metal, cannot be recycled indefinitely. What this means is that almost all plastic, when recycled, is turned into a nonrecyclable object, or something that will be recycled into a nonrecyclable object. In other words, most plastic can only be recycled 1 or 2 times before it must go to a landfill, which makes plastic recycling in general very unsustainable.

Plastic bottles

Another common form of single-use plastic is bottles. While plastic bottles can be recycled, when they are they usually get turned into fabric, which generally cannot be recycled again. It is also worth noting that most plastic bottles contain BPA, which is considered a toxic substance in some countries, including Canada, and is banned from baby bottles in the EU.

Although it isn't considered biodegradable, glass, unlike plastic, can be recycled an indefinite number of times without losing quality or purity. However, only 33 percent of waste glass is recycled in the United States, and only 40 percent of glass thrown into single-stream recycling collections (which take glass, metal, and paper products without separation, like the bins you may have in your neighborhood), is actually recycled. Some glass put into recycling bins cannot be recycled because of labels or remnants of food that the consumer did not remove, and some of it is crushed up to use as a cheap landfill cover instead of actually being recycled into new glass. Some glass simply cannot be recycled, such as baking dishes or windows, because of chemicals that are added to it. It is worth

¹¹ [“Bamboo Bags - Are They Really Eco-Friendly?”](#) nashvillewraps.com, February 26, 2010

noting that 90 percent of glass put into multi-stream recycling (where different types of recyclables are separated by the consumer, often into different bins) is recycled, as it is cleaner and easier to sort than that from single-stream recycling.¹²

The biggest issue with glass is probably its weight. This isn't the first thing to come to mind when you think of environmental costs, but the heaviness of glass means it requires more gas and energy to transport, using more resources and producing more greenhouse gasses than plastic would in the same situation. A 500 mL glass bottle weighs about 300-400 grams, whereas a plastic bottle of the same volume would weigh about 10 grams.¹³

Aluminum should also be considered here. While aluminum cans aren't a very practical solution for things like ketchup, that will be used more than once and need to be resealed, they are certainly an option for beverages. Like glass, aluminum is infinitely recyclable, but unlike glass it doesn't get detoured to make landfill cover. It is also very light and durable, causing transportation to be much more environmentally friendly than glass.

These reasons may make aluminum sound like the perfect solution for beverage packaging. However, aluminum cans (and most aluminum in general) are made from a type of aluminum ore called bauxite, the mining of which can cause serious pollution, especially water pollution, and destroys landscapes which can lead to problems such as erosion and loss of habitats and biodiversity. These issues make the raw materials of aluminum much more environmentally costly to get than those of glass.¹⁴

Germany has a much more complex and thorough recycling system than many other countries. One part is a policy where many beverages packaged in glass, plastic or aluminum have a small extra deposit, or "pfand", that the customer pays when buying them, usually about 25 cents for plastic bottles and 8-15 cents for glass or aluminum. The customer then brings back their empty bottles and cans to a special machine, often called a reverse vending machine, in their local store, which scans the bottles and cans to sort and recycle them. The customer is then given back the money they paid in deposits. This system gives consumers both an easy way to recycle and an incentive to do so, since it effectively costs money to not recycle some things. All other waste, including the rest of the recyclables, is sorted into categories at the home of the consumer, each of which has its own bin. These bins are emptied regularly, much like our trash and recycling system in the United States. One article described a large neighborhood bin with multiple slots for sorting

¹² Mitch Jacoby, "[Why glass recycling in the US is broken](#)," Chemical and Engineering News, February 11, 2019

¹³ Elizabeth Pulliam, "[The Great Debate- Plastic vs. Glass](#)," packagingschool.com, August 13, 2018 (I saw the weight statistic on a few different sites, none had accessible sources.)

¹⁴ Lee KY, Ho LY, Tan KH, Tham YY, Ling SP, Qureshi AM, Ponnudurai T, Nordin R, "[Environmental and Occupational Health Impact of Bauxite Mining in Malaysia: A Review](#)," iimed.net, December 2017 and "[Bauxite in Malaysia: The environmental cost of mining](#)," BBC.com, January 19, 2016

glass by color, and at each house a blue bin for paper, a yellow bin for recyclable plastic and aluminum, a brown bin for compostable waste, and gray bin for the leftover trash. The recycling rate of aluminum cans in Germany is 99 percent, while it is hovering around 50 percent here in the US. If we developed a way to get an aluminum recycling rate of close to 100 percent, we could theoretically have a cycle of aluminium cans that would require little, if any, mining of new aluminum ore.¹⁵

Plastic produce packaging

Another major source of single-use plastics is packaging from produce. Produce packaging helps to keep food sanitary and fresh, and reduces food waste. Some foods, such as cucumbers and heads of lettuce, are shrink wrapped for protection, and some like mushrooms, grapes, or greens are sold in plastic containers. Some of these foods cannot effectively be shipped and sold without plastic. Because of this, getting rid of single-use produce packaging would most likely mean a decrease in food diversity in some stores, such as only being able to sell cucumbers with thick skin that don't require shrink wrapping to keep them safe during transit, or selling some produce only when it is locally in season, rather than shipping it from far away. Stores might buy more produce from local farms in general, since the transport would be much shorter and simpler. There would also be less time between harvesting and selling the produce, meaning the food would require less packaging to keep it safe. People could also buy produce in bulk, although repeated handling could cause bruising. Some packaging is of course not really necessary, and could be done away with, such as barcode stickers on fruit. Cashiers could easily just type in the serial numbers for produce instead of scanning the labels.

Some packaging and food companies have begun developing alternatives to some food packaging, such as plastics made from corn, or the NatureFlex film line from Futamura.¹⁶ NatureFlex films are made from materials such as wood pulp, aluminum and resins, and can be composted in an industrial composting machine. Some of their products can even be composted in a home compost bin. The food company Alter Eco created the first plant based and compostable laminated food pouch, which they use to package their bags of quinoa, and they also use compostable packaging for their chocolate truffles. These materials can also only be composted in industrial composters.¹⁷

¹⁵ [“All About Recycling in Germany,”](#) howtogermaany.com and [“REPORT: Aluminum Can Maintains Position as Most Sustainable Beverage Package,”](#) the Aluminum association (aluminum.org), September 9, 2019

¹⁶ [“NATUREFLEX™ - COMPOSTABLE AND RENEWABLE PACKAGING FILMS,”](#) futamura.com

¹⁷ Mathieu Senard, [“Alter Eco's Gone4Good™ Packaging Eliminates Plastic Pouch Problem,”](#) sustainablebrands.com, May 11, 2016 and [“Our Packaging,”](#) Alter Eco Foods

Alternative bioplastics such as these are generally intended to be processed in an industrial composting facility, and usually cannot be composted at home. However it can be difficult to find industrial composting facilities, and often they are not widely accessible. I haven't seen these options on fresh produce anywhere, only processed foods, but it is possible that something similar could be used for produce.

Wake County, North Carolina does have a form of municipal compost. There are four sites for drop-off, called food waste recycling centers (unfortunately they don't do pick up): two in Raleigh, one in Wake Forest, and one in Knightdale. It could be impractical to use these centers if you do not live right by them as you have to save up food waste, which can become a messy health hazard after a few days. According to Sara Davarbaksh,¹⁸ these centers do send the collected waste to an industrial composting facility, meaning that any compostable plastics or similar alternative packaging can be composted there, as they will have enough heat to break down. She clarified that these types of products cannot be recycled or composted in your backyard, but any plastics labeled as compostable will be accepted at the Wake County food waste recycling centers.¹⁹

Plastic mail order packaging

Another large source of packaging, especially as online shopping becomes more prominent, is mail order packaging. Most things bought online come in boxes or envelopes filled with products like bubble wrap and packing peanuts, which go straight to the landfill. Mail order shopping can also create large quantities of greenhouse gasses, especially when consumers choose overnight or expedited delivery, causing fewer packages to be put on each truck in an attempt to ship things as fast as possible, which means more vehicles on the road than are necessary.

Many alternatives already exist to plastic-free (and bioplastic free) mail order packaging, such as corrugated cardboard alternatives to bubble wrap. For instance, Package Free Shop²⁰ ships all of their products with no plastic of any kind, using only recyclable and compostable packaging, even down to shipping labels and packing tape.²¹ However, these alternatives can use a lot of paper, which can cause other problems as discussed in the section on paper bags.

¹⁸ I spoke on the phone to Sara Davarbaksh, an environmental educator specializing in waste management who works at the Wake County waste and recycling program, and asked her some questions about the Wake County food waste recycling program.

¹⁹ "[Organic Waste and Composting](#)," "[Food Waste Recycling](#)," and "[DROP-OFF LOCATIONS](#)," wakegov.com

²⁰ Packagefreeshop.com

²¹ "[How We Pack](#)," Package Free Shop; "[Pressure Sensitive Kraft Tape in Stock](#)," uline.com; "[Green Wrap | Eco Friendly, Decorative Void Fill](#)" and "[Corrugated Bubble, Upcycled Void Fill](#)," ecoenclose.com

Plastic medical supplies

Perhaps the most difficult plastic product to replace would be medical supplies, given the high degree of sanitation they require. Biodegradable options are available for simple household bandages, such as bamboo fiber bandages,²² but supplies for hospitals would be much more difficult. Many products in hospitals are made of or packaged in plastics, which are usually single-use.²³ According to *Plastics Today*, PVC-based medical products are estimated to represent about one quarter of all plastic waste. There are certain chemicals in some medical grade plastics that cannot be recycled, and biohazards from bodily fluids and medicines can also compromise recycling. I do not see a good way to significantly reduce single-use plastic in hospitals without compromising the current high levels of sanitation they provide.

Policy Options

Not many countries have bans on single-use plastics, and most of those that do only have laws applying specifically to plastic bags. Both the EU and Canada plan to ban longer lists of single-use plastics, but they haven't released their lists yet, as neither policy will become effective until 2021. Some cities in India have more comprehensive bans including things like cups, plates and cutlery in addition to bags. Only 3 states in the US have statewide bans or restrictions on plastic bags: California, Hawaii, and New York. Connecticut, Delaware, Maine, Oregon and Vermont all have taxes or fees to restrict use of plastic bags. These 8 states, along with some separate cities, are pretty much the extent of the United States' limitations on single-use plastic. In fact, 17 states have some sort of law banning local government from restricting plastic bag use—a ban on bans, so to speak.²⁴ I would suggest thinking much bigger than just plastic bags. It's something, but it's not enough. I think there are two basic options here: a ban on producing single-use plastic (with some exceptions), or a tax/fee on buying it. I will look into both of these options.

There are two different ways a ban could be implemented. First would be to create a list of common single-use plastics with clear definitions, and ban only those specific plastics, such as the plans made by Canada and the EU. A list like this could include:

- Plastic bags (grocery, Ziploc, etc.) with a limit on the thickness of the bags so that it would be clear as to what was “single-use” and what is not;
- Plastic bottles, including beverage bottles, bottles for soaps, bottles for cleaning products, etc.

²² [PATCH brand bamboo bandages](#), Package Free Shop

²³ [“The Many Uses of Plastic Materials in Medicine - Use of Plastic in Medicine,”](#) Craftech Industries, INC.

²⁴ Sarah Rice, [“See the complicated landscape of plastic bans in the US,”](#) National Geographic, August 15, 2019

- Plastic windows in cardboard boxes
- Plastic wrap
- Plastic straws
- Plastic based cotton swabs
- Single-use polystyrene (cups, plates, packing peanuts etc.)
- Plastic packing materials such as bubble wrap
- Plastic packaging/seals (plastic around the necks of bottles, plastic shrink-wrap on food, chip bags, plastic containers for nuts etc)
- Plastic cutlery and takeout containers

A list like this could not cover every possible example of single-use plastics, but it would precisely define what was banned, and could still reduce a huge amount of plastic waste.

A second approach to a ban would be to precisely define single-use plastics, then to list exceptions to a ban, such as medical supplies and compostable plastics. However, to do something like this you would need a clear definition of single-use plastic. It may be noted that I have not yet offered such a definition. Most definitions of single-use plastic are something along the lines of ‘objects made of plastic that are intended to only be used once before they are thrown away or recycled’. However, this makes way for many potential loopholes and uncertainties. If you use a thin plastic grocery bag to scoop your cat's litter box or line a small trash can after taking home your groceries, is it still single-use? How does one tell how many times something is ‘designed’ to be used? Is there a way to regulate this? Could slightly more durable plastics such as Ziploc bags or plastic Solo cups be classified as reusable? Such a broad statement could lead to many of these potential loopholes.

Ultimately, whether or not a plastic is “single-use” depends on intent. For instance, a plastic storage container and plastic jar of peanuts may be identical in all respects except for the fact that one is sold to be reused. To avoid a ban on “plastic intended to only be used once”, peanut manufacturers could simply say that they were selling reusable containers that happened to come with peanuts in them. But of course if consumers must buy a new container every time they want more peanuts, the containers will eventually end up as waste. A law might say that nothing can be packaged in plastic and that any reusable plastic containers must be bought empty, but this would only affect some single-use plastic.

Another problem is the definition of “reusable.” Each type of single-use plastic would require a different set of rules defining what makes it reusable. For instance, a plastic grocery bag could be regulated by thickness (although that could backfire, as I will discuss later on), but that same thickness couldn’t be used to regulate the plastic handle of a cotton swab. Regulations could specify the minimum number of times an object can be used—for

instance, plastic bags must be able to carry x number of pounds over y feet z times—but this would change based on what type of single-use plastic you are regulating, and would be very difficult to enforce. The only commonalities between different types of single-use plastic are that they are made of plastic (a broad category of materials) and intended for a single use (a matter of intent). Therefore, I do not think a simple and all-inclusive definition of single-use plastic is possible, and any laws based simply on “single-use plastic” would not work well, at least to start.

An alternative to a ban is a tax or a fee on single-use plastics. For example, multiple reports say that a 5 to 10 cent fee on plastic bags can dramatically reduce the number of consumers who use single-use bags. A study in Australia found that with no restrictions on plastic bags, consumers chose single-use bags 67 percent of the time, reusable bags 16 percent of the time, and no bag 17 percent of the time. In grocery stores with a fee on single-use bags, consumers chose single-use and reusable bags equally about 31 percent of the time, and chose no bag at all 39 percent of the time.²⁵ A small fee can thus have large effects.

Therefore, I think we should not restrict people's actions, but rather give them the incentive to do the best thing. One article noted that many stores have responded to plastic bag bans by making thicker plastic bags that are just barely sturdy enough to exempt them from the ban, rather than coming up with alternatives. On the contrary, many cities have had great success with fees and taxes on plastic bags, and little retaliation against them. I would suggest a similar policy, but on all single-use plastics. This could also extend to the manufacturers, making it more expensive to produce single-use plastics.²⁶

I would first enact a tax on all plastic, single-use or not. This is a simple place to start, and gives manufacturers an incentive to switch to non-plastic packaging wherever possible. This would also create less opportunities for loopholes, and given the generally positive reactions to taxes on plastic bags, this would probably be met with less resistance than a ban. If the tax failed to reduce plastic waste, I would consider other options such as a ban on plastic packaging, although as explained above this would be difficult to define and enforce.

Municipal composting could help to solve many of these waste problems, since composting is an ideal closed loop form of waste disposal. I would specifically suggest household pickup of compost, not just municipal drop-off spots, as it is not practical for most people to compost in their own yards and homes. In such a system, each household would receive a compost bin that would be regularly emptied, like trash and recycling bins. Accepted waste should include everything that is compostable in a backyard setting, including not only

²⁵ [“Plastic Bag Fees,”](#) [ibagatatime.com](#)

²⁶ Matthew Zeitlin, [“Do plastic bag taxes or bans curb waste? 400 cities and states tried it out.”](#) [vox.com](#), August 27, 2019

yard waste but also food scraps, which many industrial composting facilities do not accept. In addition, municipal facilities should accept products labeled as “biodegradable” or “compostable,” such as compostable plastic cups that can be composted only in industrial composting facilities with sufficient heat and aeration, not in a natural backyard setting. Such products are presently an excellent choice for festivals, restaurants, etc., but not practical for the average person. For compostable plastics to become mainstream and accessible to the general public as a plastic alternative, municipalities must combine household pickup with industrial composting.

Conclusion

Single-use plastics, while they provide many conveniences in our everyday lives, are detrimental to the environment in several ways. Plastics are deeply ingrained into our society, and many of us use them in almost every aspect of our everyday lives. While it may be quite difficult to remove and replace single-use plastics, especially as many of them are considered essential for health and sanitation purposes, I think we need to start thinking very seriously about how to begin taking steps away from them. I would suggest starting by putting a tax on plastic, as I discussed, and I would also instate nationwide municipal composting. This isn't enough to be a solution to this entire problem, but it's a start. Single-use plastics come with a high environmental price, and I believe that as a society we need to turn away from our current culture of single-use trash and start to replace it with sustainable alternatives that are less harmful for the environment.