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Microplastics in the Big Apple: A look into plastic pollution of New York City Waters

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Abstract:

This paper addresses the issue of the presence of microplastics in NYC waters and how existing policy, in combination with a lack of research, fails to acknowledge the risk and harm of this type of pollution. Additionally, it presents the Bronx River as an example of a specific body of water in New York City and employs the following disciplines to analyze microplastic pollution. Chapter 1 uses ecological research to define microplastic pollution and discuss how this type of pollution is a problem far more vast and complicated than it is widely considered to be. Chapter 2 delves into environmental health concerns that microplastic pollution presents to both human and non-human species. Chapter 3 demonstrates how urban planning is instrumental to the health of those residing in urban areas and how a lack of proper management allows microplastics to infiltrate aquatic ecosystems in New York City through poor sewage management and food chains. In Chapter 4, the Bronx River and its history of pollution is examined, along with the correlation of plastic pollution with public health issues in a historically socioeconomically disadvantaged area. Chapter 5 integrates the above chapters as a list of policy actions to mitigate plastic pollution in NYC water bodies, especially the Bronx River.

Keywords: microplastics, plastic pollution, trophic levels, aquatic ecosystems, New York City waters

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Introduction: What are Microplastics? The Children of Plastic Pollution

In our modern world plastics are as ubiquitous as air. They are in our homes, from toothbrushes to dog collars to single-use cups of applesauce, all the way down to our underwear and socks. Plastics are in our environment in even the most remote locations- from the top of Mount Everest, to the bottom of the Marianas trench. They are in our food, water, air and are even within our own bodies down to the microscopic level of our capillaries. It is as if we are living in our own version of a Barbie dream house full of shiny bright plastics- but instead of an idyllic life of toys we are subjected to the pollution of plastic. The problem is that this is our reality, and plastics are not just a versatile material used in all aspects of life— they are an active threat to the health of our planet. Since the beginning of widespread plastic use in the 1960s, plastics have taken over our lives and are choking life out of the Earth. The durability of plastic is its greatest strength, and yet the biggest downfall of this invention. Plastic is non-biodegradable, which means that it does not decay at a rate in which our fragile ecosystems would be able to handle the waste created from plastic production and consumption. Some plastics take as long as over 1,000 years to decompose. In this paper, I will investigate the largely unknown phenomenon of microplastic pollution (which are plastics smaller than 5 mm), and its effect on the environment, which will center on New York City waterways such as the Hudson and Bronx Rivers. Chapter one provides a foundation for the chemical and biological science of plastics (polymers), which gives insight as to why plastics are so insidious to the natural environment and why efforts to mitigate this issue have largely failed.

Chapter two will delve into the presence of microplastics specifically in the New York City Bay area. Urban planning, design, and infrastructure (or lack thereof) will be used as a guideline to examine why New York City has failed to prevent and stop microplastics from

polluting their waters. Chapter three discusses the environmental health crisis that we are experiencing globally due to the unforeseen inundation of microplastic pollution in our food, water, air and therefore within our own bodies. Chapter four uses the Bronx River as a case study for a NYC body of water that is proven to contain microplastics—not only within its waters but also in the animals that inhabit it. I will also briefly delve into the history of the Bronx's recovery from centuries of pollution from various pollutants and sources. Finally, in Chapter 5 several policies are proposed to prevent further plastic pollution and initiatives that will aid in cleaning up and disposing of the plastic still within our environment today.

Chapter 1: Plastics! They're Everywhere!

What are plastics? While plastic may play a huge role in our lives, many people are ignorant as to what plastics actually are. Plastics, simply put, are a group of substances called "polymers." Polymers "are produced by the conversion of natural products or by the synthesis from primary chemicals generally coming from oil, natural gas, or coal."[1] Plastics are well-known polluters of our environment for both chemical and physical reasons. The very production of plastics causes pollution because they use fossil fuels during the energy consumption for manufacturing, and they are made out of fossil fuels which will later emit emissions that can be classified as greenhouse gas emissions. "Plastic, which is a petroleum product, also contributes to global warming. If plastic waste is incinerated, it releases carbon dioxide into the atmosphere, thereby increasing carbon emissions."[2]

The reason why plastics are so dangerous to our environment is not solely based on how they are manufactured, but also because of what happens when they are left to decompose in a

[1] "Plastics 101" *Overview*, plastics.americanchemistry.com/How-Plastics-Are-Made/d.

[2] "Marine Plastics." *IUCN*, 5 Dec. 2018, www.iucn.org/resources/issues-briefs/marine-plastics.

landfill or are left in an organic environment. Plastics do not decompose; they are not a biodegradable substance which means that they can not decompose naturally within our environment. Therefore, plastics are continuing to pollute and fill our environment with no way of eliminating this substance. This is due to the fact that bacteria cannot decompose plastic therefore it is unable to organically decompose. "... most conventional plastics such as polyethylene, polypropylene, polystyrene, poly(vinyl chloride) and poly(ethylene terephthalate), are non biodegradable, and their increasing accumulation in the environment has been a threat to the planet." [3]

The concerns over plastic build-up and pollution has led to a public interest in recycling as a solution to this specific type of pollution. The idea is that one can use waste plastic products and convert them into new products that can be reused over and over again rather than manufacturing new plastics from raw materials. However, the amount of plastic pollution we are now facing is so incredibly large that solely recycling is akin to a band-aid solution. Furthermore, there is a lack of recycling programs, facilities, and accessibility due to the financial incentives that the fossil fuel industries have in regards to manufacturing more plastics.

Pollution. An alternative to recycling is the process of incineration in which plastic waste is taken to plants to be burned. However, this process produces huge amounts of toxic emissions and ash that is harmful to our health. The incineration of plastic can lead to severe health complications such as heart disease, nausea, and damage to the nervous, kidney, and reproductive systems. The ash and air pollution from these emissions have also been known to aggravate respiratory diseases like asthma and emphysema. Furthermore, the chemicals and dioxins from the ash itself settle on land and can be found on crops and water systems— which

[3] Tokiwa, Yutaka, et al. "Biodegradability of Plastics." *MDPI*, Molecular Diversity Preservation International, 26 Aug. 2009, www.mdpi.com/1422-0067/10/9/3722.

eventually end up in our food,water and body.[4] The vast majority of plastic waste eventually end up in water systems like rivers and, most notably, the ocean. About 71% of the Earth is made up of water or some type of aquatic environment. It is arguably the most important ecosystem service known to man.. Plastic pollution threatens all services that water provides: cultural, provisional, regulating and supporting. We can see how the build up of plastic is affecting our planet by looking at the instance of The Great Pacific Garbage Patch, which is a floating island of a collection of marine debris in the North Pacific Ocean. Most marine plastic pollution, like seen in The Great Pacific Garbage Patch, comes from single-use plastics like straws, water bottles, and plastic bags. These items are used by millions of people, every single day, usually for no more than an hour and then are thrown away where the item will continue to exist for the next thousand years. These plastic items are left in our marine environments where they slowly break apart into smaller and smaller pieces without actually decomposing. During the time in which plastic is floating through the currents the plastic debris may be consumed by marine life, or, alternatively, the debris sinks to the ocean floor where it is embedded into the sea floor or consumed by benthic organisms.

As previously mentioned, plastic breaks down into smaller and smaller pieces, eventually becoming microplastics. Microplastics are exactly as the name implies: they are small particles of plastics less than 5 mm in length that pollute our environment. There are several types of microplastics: small granules of plastics found in cosmetics, fibers from synthetic fiber such as nylon, and fragments from larger pieces of plastics. Microplastics are created by various processes, most notably, they are manufactured already as a microplastic (for example facial

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[4] "(PDF) Toxic Pollutants from Plastic Waste- A Review." *ResearchGate*, www.researchgate.net/publication/305892272_Toxic_Pollutants_from_Plastic_Waste-_A_Review.

wash beads), or are deteriorated by erosion and photodegradation. Erosion of plastics commonly occurs on land surfaces such as beaches where abrasion caused by waves causes plastic to physically deteriorate into smaller pieces. Photodegradation, on the other hand, is the process in which UV ray exposure is the cause for plastic breakdown; this process takes more time as sunlight is diverted away from the debris due to the reflection of water.

Microplastic pollution is just as, if not more, insidious as larger plastic debris pollution. Besides being a visual nuisance, larger plastic pollution has been known to strangle, embed, or be consumed by organisms. One report from National Geographic included research in which scientists found that 90% of all seabird species today have ingested plastic at one point in their lives. Unfortunately, there is not a lot of research that has been conducted on microplastics but what is known is that microplastics, while incredibly small, have a large impact on our environment. Due to the small nature of microplastics they have infiltrated food chains and can be passed through trophic levels. It is obvious that any foregin substance that has the ability to infiltrate and be passed through food chains is cause for concern. The ability of plastics to pass through food chains signifies that humans are inevitably consuming microplastics as well: either through consumption of water or of food such as fish. The immense amount of microplastics present in our environment shows that there is an uncontrollable quantity of waste being produced that is not being managed.

American Consumerism and Plastic.Plastics are a physical embodiment of the American consumerist culture- they are bright, shiny, and new but lack sustainability. The United States is a prime example of a hyper-consumerist society- in which one lives well beyond their means and resources. American consumerism is at the forefront of how the country sees itself and how it is seen by other countries as well, it is a nation of wealth and excess at the expense of the resources

of the less developed. For wealthy nations like the United States, consumption goes beyond the bare necessities of food, energy resources and other items for survival. According to a report, while the United States contains less that 5 percent of the world's population, "the U.S. uses one-third of the world's paper, a quarter of the world's oil, 23 percent of the coal, 27 percent of the aluminum, and 19 percent of the copper"[5] which demonstrates the excess use of resources used by Americans. This mass acquisition of wealth and natural capital has radically changed America's basic needs for survival into glorified commodities for the economy. Consumerism in the United States can be attributed to an excess amount of both necessities and "things"- unnecessary items of all sorts such as toys, cosmetics, cars, etc (which are often packaged or manufactured with plastics). Therefore, much of America's consumption of items and therefore disposal of said items become plastic waste. According to a study in 2016, "...the U.S. population produced the largest mass of plastic waste of any country in the world and also had the largest annual per capita plastic waste generation of the top plastic waste–generating countries (>100 kg)."[6]. As seen in Figure 1,in 2016, the United States produced nearly 42 million metric tons of plastic waste- whereas India the second largest generator

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5 "Use It and Lose It: The Outsize Effect of U.S. Consumption on the Environment." Scientific American. September 14, 2012. https://www.scientificamerican.com/article/american-consumption-habits/.

6 Law, Kara Lavender, Natalie Starr, Theodore R. Siegler, Jenna R. Jambeck, Nicholas J. Mallos, and George H. Leonard. "The United States' Contribution of Plastic Waste to Land and Ocean." Science Advances. October 01, 2020. https://advances.sciencemag.org/content/6/44/eabd0288.

of waste- produced only 26.3 million metric tons of waste.

It should be noted that while India has triple the population size of America (about 8.10

Table 1. Countries with the highest plastic waste generation in 2016. Calculations using data reported in (*18*), with a refined estimate for the United States (bold text). EU-28 countries are reported collectively (italics).

Country	Plastic waste generation (metric tons)	Total waste generation (metric tons)	% Plastic in solid waste	2016 Population (millions)	Per capita plastic waste generation (kg/year)
United States	**42,027,215**	**320,818,436**	**13.1**	**323.1**	**130.09**
United States	34,020,748	263,726,732	12.9	323.1	105.30
EU-28	*29,890,143*	*243,737,466*	*11.7*	*511.2*	*54.56*
India	26,327,933	277,136,133	9.5	1,324.5	19.88
China	21,599,465	220,402,706	9.8	1,378.7	15.67
Brazil	10,675,989	79,081,401	13.5	206.2	51.78
Indonesia	9,128,000	65,200,000	14.0	261.6	34.90
Russian Federation	8,467,156	59,585,899	14.2	144.3	58.66
Germany	6,683,412	51,410,863	13.0	82.3	81.16
United Kingdom	6,471,650	32,037,871	20.2	65.6	98.66
Mexico	5,902,490	54,151,287	10.9	123.3	47.86
Japan	4,881,161	44,374,189	11.0	127.0	38.44
Thailand	4,796,494	27,268,302	17.6	69.0	69.54
Korea, Rep.	4,514,186	18,576,898	24.3	51.2	88.09
Italy	3,365,130	29,009,742	11.6	60.6	55.51
Egypt, Arab Rep.	3,037,675	23,366,729	13.0	94.4	32.16
France	2,929,042	32,544,914	9.0	66.9	43.81
Pakistan	2,731,768	30,352,981	9.0	203.6	13.42
Argentina	2,656,771	18,184,606	14.6	43.6	60.95
Algeria	2,092,007	12,378,740	16.9	40.6	51.59
Malaysia	2,058,501	13,723,342	15.0	30.7	67.09
Spain	1,832,533	20,361,483	9.0	46.5	39.42

Figure. 1 Law et al, *Countries with the Highest Plastic Waste Generation in 2016* (Science Advances. October 01, 2020).

million more people), it still produces approximately 50% less waste than America.[7] The most significant market for plastic today is packaging, which accounts for 42% of all plastic ever manufactured as a result of the global change from reusable to single-use packaging (including containers). Packaging has the shortest lifetime of any product. Since most plastic packaging is designed for a single use, it leaves the economy the same year it is made.[8] The fact of the matter

[7] ibid

[8] Plastic & Climate: The Hidden Costs of a Plastic Planet." *Human Rights Documents Online*. doi:10.1163/2210-7975_hrd-9986-20190012. Page 27

is that Americans consume a multitude of goods, and a majority of those goods are made out of plastic.

Despite the knowledge that is known in regards to the horrors of plastic pollution and the negative consequences of overconsumption, Americans and other countries continue to develop and generate waste at an exponential rate. This begs the question of: “Why do we continue to be unsustainable despite the implications?”. The simple answer is: capitalism. The United States and most developed nations have an economic structure based on capitalistic theory- the most detrimental aspect possibly being the unchecked accumulation of capital and goods. The theory is not only that general well being is linked to a higher standard of living, but that consumption and material possessions are at the heart of happiness.[9] A consumerist society is one in which people spend a significant amount of time, energy, money, and contemplation on the act of "consuming." In a consumerist culture, the general consensus is that consumption is inherently good, and further consumption is even better. In essence, the unsustainable nature of American life and practices is a culture in and of itself, and it is the very foundation of our capitalist economic system, which requires us to manufacture and consume on an ever-increasing scale in order to generate wealth.

At times, it is in better economic interest for fossil fuel industries (such as big oil) to continue to produce new plastics instead of recycling.Plastic output has outpaced recycling by five times in the last decade, despite efforts to promote recycling. Increased plastic recycling is one solution, but it only has a small impact on the plastic waste crisis. These industries are once again putting the health of our environments at risk for their own economic gain. The Plastics Industry Association is just one example of a lobbyist group that continuously fights to prevent bans of plastics, such as plastic bag bans in grocery stores, as the industry is incredibly

[9] Wright, Erik Olin, and Joel Rogers. *American Society: How It Really Works*. Norton, 2015.

profitable. Therefore we are not only facing an uncontrollable environmental crisis but also a moral one in which environmental activists have to fight legal battles against an industry that is projected to be worth over $1 trillion dollars in 2020.[10] There is essentially a complete and utter disregard for the Earth and its fragile ecosystems in the face of the prioritization of consumption and profit from said consumption by capitalist society.

It is unnatural and against the natural systems of the Earth to be capitalist- unchecked exponential growth- is not sustainable and never will be therefore our society as we know it is inherently incompatible with the planet we inhabit.

Waste Management. Upwards of 50% of all plastic ever produced has been manufactured in the last 15 years, and the magnitude of production rises - year after year.[11]

The continuous increase in global plastic production and consumption has outpaced the majority of conventional waste disposal methods by a significant margin. In fact, just a small percentage of plastic waste has the viability to be recycled in an economical or practical way. The implication of this is that humanity is now overflowing the environment with plastic waste at a rate so rapidly that our municipal waste system cannot maintain the massive input of waste .Over the course of approximately seven decades (1950-2015) 60% of the amount of all plastic manufactured was disposed of and accumulated within the natural environment or landfill sites.[12] To put this number in perspective, that is nearly 4.9 billion tons of plastic waste that is just sitting

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[10] *Plastics – the Facts 2017*. www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf.

[11] "Plastic & Climate:The Hidden Costs of a Plastic Planet." *Human Rights Documents Online*. doi:10.1163/2210-7975_hrd-9986-20190012, page 5

[12] "Plastic & Climate:The Hidden Costs of a Plastic Planet." *Human Rights Documents Online*. doi:10.1163/2210-7975_hrd-9986-20190012, page 43

on our planet without being recycled not even once. Additionally, from that amount, “60 percent entered the environment (either via landfill or marine and terrestrial litter) 12 percent was incinerated, and only 9 percent was recovered for recycling”.[13]

“So why are plastics not being recycled?” Many people have the notion that we can end plastic pollution and salvage the environment through the effort of recycling- the mantra “reduce, reuse, and recycle” is one that is embedded in many American’s vision of environmental activism. However, the idea of recycling as a circular production of plastic- one in which we will reuse the same plastics forever as they do not decompose naturally- is extremely flawed. Recycling is not feasible the majority of the time for a multitude of reasons including but not limited to: infrastructure issues, illegal disposal of waste, economic and environmental efficiency and other factors. While the technology exists to recycle the majority of plastics, there is a lack of infrastructure and organized collection of plastics that prohibits all but the most common types of plastic from being recycled. As seen in table 1, there are a variety of resin codes for plastics- seven in total- however, while there are only seven resin codes there are thousands of different plastics. The implication of the chemical diversity of plastics means that they cannot be mixed during the recycling process or it will be rendered unusable.

As stated by the Society of the Plastics Industry (who provided a comprehensive standard for plastic identification), “The code was not intended to be — nor was it ever promoted as — a guarantee to consumers that a given item bearing the code will be accepted for recycling in their community.”.[14]The regulatory authority that mandates recycling protocols is not federally regulated but rather is based at a local municipality level- therefore adding another reason as to why the system is egregiously inefficient. Even the most common types of plastics are facing a

[13] ibid

[14] *Recycling Plastic: Complications & Limitations*
www.alexandriava.gov/uploadedFiles/tes/solidwaste/info/RecyclingPlasticComplications.pdf

crisis,“domestic recycling of the three top plastic bottle types (#1 PET, #2 HDPE and #3 PP) stayed flat between 2015 and 2017.”, in which they are not being responsibly or recycled at a rate that would garner any environmental gain.[15]

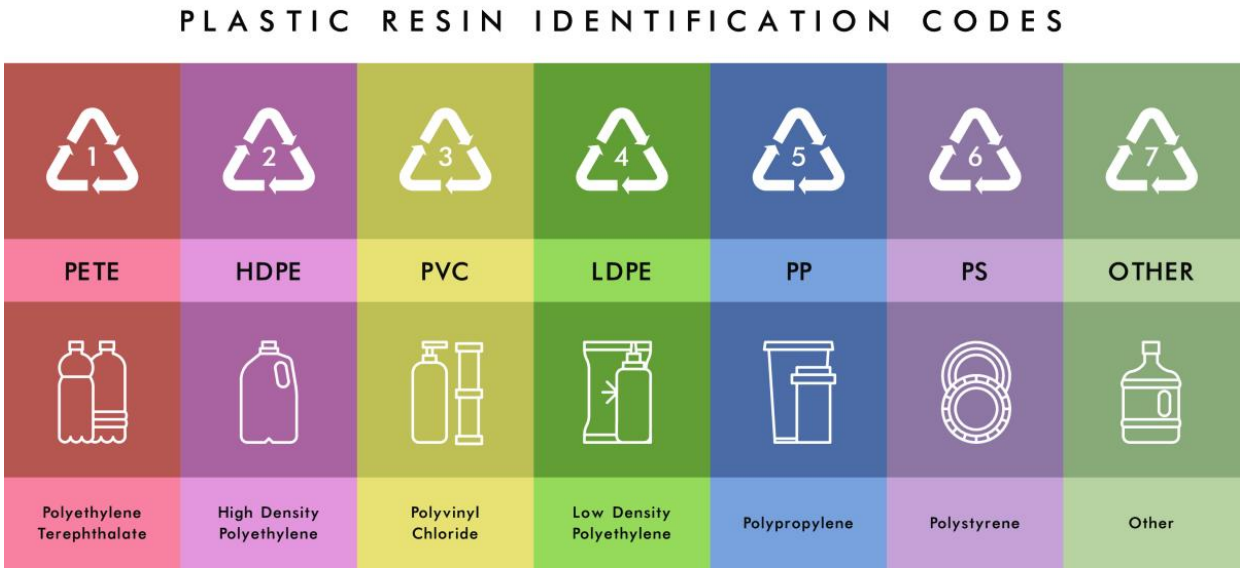

Table.1

Another reason is that it is too expensive economically and not effective for the environment to recycle. As a commodity, used plastic has a low value and use due to its degradation after each recycling cycle. Therefore, corporations have little economic incentive to recycle as it is more economically sound to purchase or produce virgin plastic. Additionally, the process that it takes to recycle non-virgin plastics is often more arduous and unsustainable in practice- therefore voiding any environmental benefit that may have occurred. As a result, most plastic is only recycled once before being discarded.Many vehicles and personnel are needed to collect widely dispersed waste, labor and equipment are necessary to collect the waste, and

[15] Plastic Pollution Coalition. "Six Times More Plastic Waste Is Burned in U.S. than Is Recycled." Plastic Pollution Coalition. April 30, 2019. https://www.plasticpollutioncoalition.org/blog/2019/4/29/six-times-more-plastic-waste-is-burned-in-us-than-is-recycled.

processing facilities are required to clean and process the waste.The economic realities of cheap new plastic production and low-cost oil and gas production make mechanical and chemical recycling processes economically uncompetitive and impractical at commercial scale.[16] As mentioned in the previous chapter, corporations are driven by the capitalistic need to cut costs as much as possible in order to garner as much profit possible. Therefore, this dynamic disregards any environmental concern due to the practice not being profitable- profit over the people.

The exportation of plastic waste overseas to Asian countries is a profitable and booming business in the United States. Plastic waste is exported for two main reasons: it is more economically advantageous and practical to export the overwhelming amount of waste to another country and have them be responsible for disposal and recycling. In particular, it was mutually beneficial for this act of trade to occur between the United States and China, "For decades, China handled the recycling of almost half of the world's discarded materials, because its manufacturing sector was booming and needed these materials to feed it. In 2016, the U.S. exported 16 million tons of plastic, paper and metals to China.". [17]However, this trade agreement proved to be disastrous in several ways as, "30 percent of these mixed recyclables were ultimately contaminated by non-recyclable material, were never recycled" and these waste items

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[16] Plastic Pollution Coalition. "Six Times More Plastic Waste Is Burned in U.S. than Is Recycled." Plastic Pollution Coalition. April 30, 2019. https://www.plasticpollutioncoalition.org/blog/2019/4/29/six-times-more-plastic-waste-is-burned-in-us-than-is-recycled.

[17] 13, Renee Cho |March, Renee Cho, Judith Piazza, Victor Villegas, Don Gordon, Emily B, Jennifer Kuemin, Anonymous, Peter L, John Doe, Barry, Jon Thaler, Sarah Fecht, David S, Darryl Forest, Bill, Alia Rain Smith, Lawrence M, Mike Pavilon, Brian Coyle, Carly, Catherine, Scott, and Jay Meyre. "Recycling in the U.S. Is Broken. How Do We Fix It?" State of the Planet. December 08, 2020. https://news.climate.columbia.edu/2020/03/13/fix-recycling-america/#:~:text=Why recycling isn't working,be processed in certain facilities.

entered the environment ultimately polluting the Chinese natural capital and ecosystems[18]. The recent implementation of the "National Sword Policy" by the Chinese government has severely limited the influx of plastic waste that may be purchased from the United States. Therefore, in turn, this has caused plastic waste to be exported to shipped to nations with low labor costs and inadequate environmental regulations such as Cambodia, Bangladesh, Ghana, and Laos.[19]

In addition to the economic incentive that is presented with the exportation of waste, the United States would not have the infrastructure or federal oversight to be able to have a comprehensive recycling program. If it were not for this exportation, the United States would currently be overflowing with pollution and trash as it is scarcely managed even now. According to a study, The United States exported 1.99 million metric tons of waste to nearly 90 different trade partners in 2016. The majority of this shipment was of course sent to Asia (China and Hong Kong primarily) and, "Of this amount, more than 88% of this waste was sent to nations who were reported to have greater than 20% mismanaged waste", which means that America's mismanagement of waste was further inadequately managed and lost to the environment. This phenomenon is most clearly presented by the same study, " ..estimate of between 25 and 75% of plastic waste discarded during the processing of plastic and paper scrap that was inadequately managed in receiving countries that have greater than 20% inadequately managed waste. This contributes an additional 0.15 to 0.99 Mt of plastic waste generated in the United States that likely entered the environment.".[20]

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[18] ibid
[19] ibid
[20] Law, Kara Lavender, Natalie Starr, Theodore R. Siegler, Jenna R. Jambeck, Nicholas J. Mallos, and George H. Leonard. "The United States' Contribution of Plastic Waste to Land and Ocean." Science Advances. October 01, 2020. https://advances.sciencemag.org/content/6/44/eabd0288.

Incineration has been proposed as an alternative to recycling or landfill management, but this method of disposal may even be more insidious than plastic waste itself. As previously mentioned, the difficulties regarding plastic prevent a comprehensive recycling effort which in turn, makes incineration the more appealing option. Consequently, approximately six times more post-consumer plastic waste is burned in the U.S. than is domestically recycled.[21]

The idea behind incineration is simple: to gather waste and burn it which would reduce the amount of volume of waste but also be used as a way to generate fuel and therefore energy.[22]While this may seem like an advantageous resolution for the plastic waste crisis, the incineration of plastics has many repercussions that affect the environment, public health, and dissuade the public from being aware of the severity of the crisis. Additionally, in 2018 the United States recycled less than 3% of municipal solid waste domestically and instead incinerated more than six times as much waste, however it is suggested that, "The ratio may have been even higher, but cities are reluctant to publicize the fact that plastic is being sent to incineration instead of recycling.".[23]

The public aversion to incineration is also aggravated by the health concerns it presents. There are concerns that waste to energy plants are emitting by-products into the atmosphere that could cause air pollution and therefore negative health consequences. Possible air contaminants that may be emitted by waste incineration include but are not limited to : ".(mercury, lead, and cadmium, among others), organic compounds (dioxins like polychlorinated dibenzo-p-dioxins, PCDD) and furans, PAHs, VOCs, and other POPs, including polychlorinated dibenzofurans

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[21] Plastic Pollution Coalition. "Six Times More Plastic Waste Is Burned in U.S. than Is Recycled." Plastic Pollution Coalition. April 30, 2019. https://www.plasticpollutioncoalition.org/blog/2019/4/29/six-times-more-plastic-waste-is-burned-in-us-than-is-recycled.

[22] Plastic & Climate: The Hidden Costs of a Plastic Planet." *Human Rights Documents Online*. doi:10.1163/2210-7975_hrd-9986-20190012. Page 43

[23] ibid

(PCDF), PCBs, and hexachlorobenzene (HCB),233 acid gases (including sulphur dioxide and hydrogen chloride), particulates (dust and grit), nitrogen oxides, carbon monoxide, and carbon dioxide (CO2).[24] The concern of these emissions pertain to the fact that smoke, ash, and particulate matter from the burning of plastic waste can arise a variety of respiratory health issues such as asthma, cardiac, and inflammatory diseases. Additionally, PCDF and PCBs are proven carcinogenic emissions and the metals released have also been linked to high toxicity levels within neurological systems.[25] The issue with particulate matter from air pollution is that it can travel long distances- therefore these contaminants can affect communities far from the source and have the potential to contaminate soil, water, and be absorbed through skin contact.[26]

The most viable method to prevent the occurence of plastic waste entering the environment would be to simply produce less plastics- especially those that are not practically or economically recyclable or single-use plastics for convenience. This would effectively prevent more plastics from entering the environment especially those with low value or frequency of being recycled. Additionally, the implementation of extended producer responsibility, or ERP, would be an efficient step in the right direction. Extended producer responsibility is a method specific to the recycling industry crisis that involves adding all of the environmental costs connected with a product throughout its life cycle to the product's market price. The function of this method would be to place responsibility not on the consumer but the producer of said product which would encourage innovation to improve upon design for the better of the environment.[27]

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[24] Plastic & Climate: The Hidden Costs of a Plastic Planet." *Human Rights Documents Online*. doi:10.1163/2210-7975_hrd-9986-20190012. Page 43

[25] ibid

[26] ibid

[27] California, State Of. Product Stewardship and Extended Producer Responsibility (EPR). https://www.calrecycle.ca.gov/epr#:~:text=Extended Producer Responsibility (EPR),,design changes that minimize negative.

Chapter 2: Microplastics In the Big Apple: An Infrastructure Failure

Microplastics are like an invasive species; they infiltrate even the most remote environments and wreak havoc on the ecosystem. Plastic pollution in our oceans and rivers find their way there by a variety of factors which include but are not limited to: littering, illegal dumping (or general waste mismanagement), archaic sewage systems, and, most surprisingly: laundry. For New York City, all of these issues have caused microplastic pollution to accumulate in our waters.

New York City, a vast metropolis of 4 islands and one peninsular borough, relies heavily on the 12 distinct waterways of fresh, brackish, and marine water that surround and support the city. The rivers, beaches, and bays that reside in NYC are both cultural and financial hubs that allow the city to thrive. Simply put, New York would not be the great city that it is today without its waterways. The most notorious waterway: The New York Bay, where the mouth of the Hudson River at the end of Manhattan flows into the Atlantic Ocean along the American East Coast. Recent studies have unfortunately demonstrated evidence of microplastic pollution in the Hudson River. According to the study there are an estimated "165 million plastic particles floating in New York Harbor and nearby waters at any given time."[28] The study was conducted using samples collected by trawler boats floating through the greater New York Harbor but more specifically the "...East River, the mouth of the Hudson River and New Jersey's Passaic River

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[28]Meola, Sandra. "Microplastics in the NY-NJ Harbor Estuary," n.d. https://www.nynjbaykeeper.org/wp-content/uploads/2019/05/ClearWaters-Microplastics-in-the-NY-NJ-Harbor-Estuary.pdf.

and Raritan Bay."[29] Reportedly, on average, there was a total concentration of 256,322 particles of plastic per square kilometer.[30]

Home to over 8 million people, New York CIty is the center of the latest technological, financial, and cultural advancements in our country and even the entire world. However, one part of NYC that has been neglected time and time again for years is the sewage system that is over 150 years old with little to no refurbishing or initiative to update the system. Approximately 60% of New York City utilizes a Combined Sewage System (CSO) in which a single pipe carries both sewage and stormwater runoff[31] from buildings into the underground pipe system and then through this network the water is transported to one of the city's fourteen wastewater treatment plants where it is treated[32]. This system works well during most weather conditions, particularly dry days, however, during times of moderate rain or storms, the system is quickly overwhelmed. Unfortunately, this phenomenon creates a huge problem where this mixture of raw sewage and stormwater runoff full of pollutants are able to bypass water treatment plants. When this occurs, this mixture of polluted water is instead discharged directly into the local waterways (rivers, streams, beaches etc.) at up to 460 different locations within the five boroughs.[33] Every year, approximately 20 billion gallons of polluted run-off and raw sewage bypass these systems and

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[29] Meola, Sandra. "Microplastics in the NY-NJ Harbor Estuary," n.d. https://www.nynjbaykeeper.org/wp-content/uploads/2019/05/ClearWaters-Microplastics-in-the-NY-NJ-Harbor-Estuary.pdf.

[30] ibid

[31] Storm water runoff is water that is not absorbed by surfaces and instead flows over them, usually flowing into drains and sewers.

[32]"Combined Sewer Overflows," Combined Sewer Overflows - DEP, accessed December 24, 2020, https://www1.nyc.gov/site/dep/water/combined-sewer-overflows.page, 1.

[33]Clara Chaisson. "When It Rains, It Pours Raw Sewage into New York City's Waterways." NRDC, March 13, 2019. https://www.nrdc.org/stories/when-it-rains-it-pours-raw-sewage-new-york-citys-waterways.

are dumped into surrounding waters.[34] Being the large industrious city that it is, New York City has an extremely high amount of impervious surfaces, or surfaces such as brick, pavement, roofing, or asphalt. Impervious surfaces, as the name implies, are areas that cannot be penetrated by rainwater. These surfaces prevent infiltration of water into soil, therefore being a hazard to water quality. These types of surfaces negatively affect water quality "by increasing the volume and magnitude of stormwater and facilitating the delivery of pollutants into receiving waters."[35] Due to the fact that these surfaces are not capable of absorbing water it strongly impacts the volume of run-off water during certain weather conditions like rain usually. Only one-tenth of an inch of rain per hour is enough to overwhelm the CSO system in NYC and what occurs is a huge amount of water

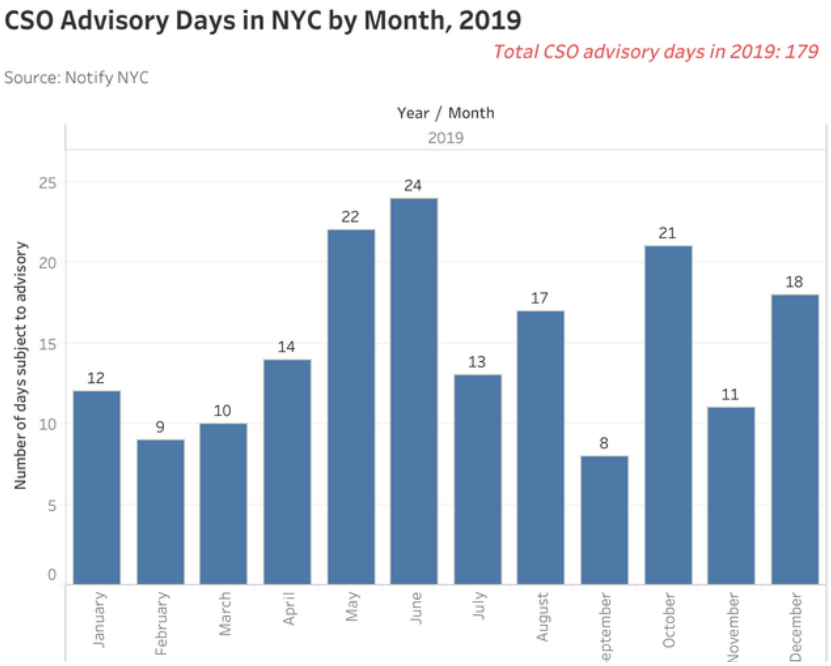
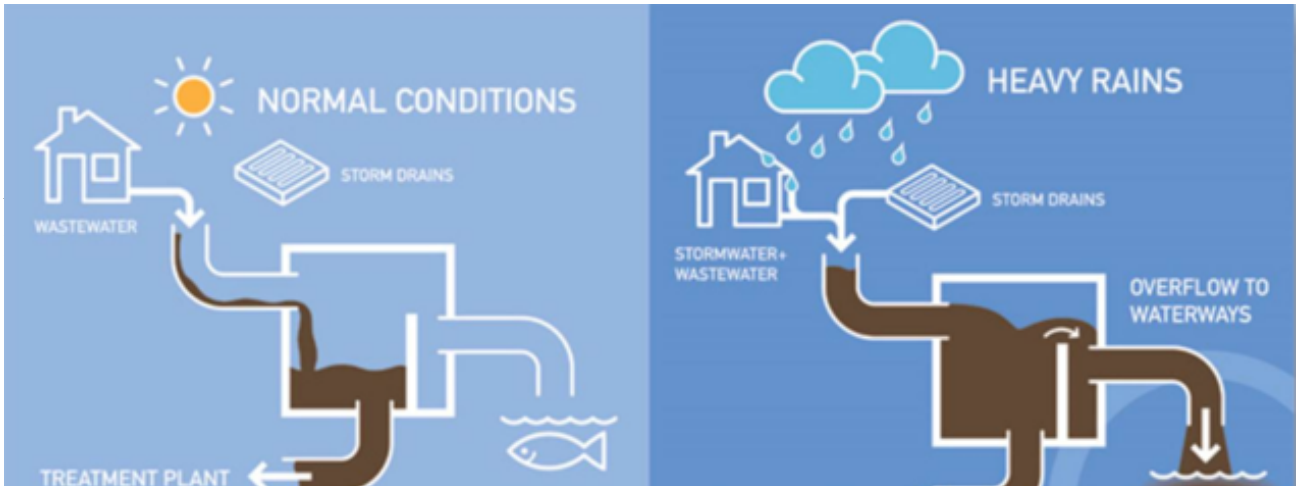


Figure 2. *CSO Advisory Days in NYC by Month,*(Notify NYC 2019)

[34] ibid
[35] Marc A Yaggi, "Impervious Surfaces in the New York City Watershed," *Fordham Environmental Law Review* 12, no. 3 (n.d.), https://core.ac.uk/download/pdf/144232408.pdf, 496.

streaming into storm drains that carry pollutants into these systems. According to figure 1, obtained from Notify NYC, a _____, there were around 179 CSO advisory days in 2019, and nearly a 50% chance on any given day that urban run-off and sewage were polluting water somewhere in New York City.[36]

The question remains as to what the failure of New York City's underground nexus of pipes has to do with microplastics. The combination of urban stormwater runoff and untreated sewage water flooding into NYC waterways is one that has the potential to pollute these vulnerable waters with both macro and micro plastic pollutants. As plastic debris (bottles, bags, food containers, etc,) is scattered throughout city streets in the form of litter and also waste mismanagement, it is often swept directly into storm drains and therefore directly into the sewage system where currents of water and other forms of friction cause the plastic to break off into smaller particles, much like the process in rivers or oceans. Although little research has been conducted on this phenomenon specifically within NYC, it has been confirmed in other studies



that “urban...stormwater runoff are direct pathways for land-based microplastics into freshwaters.”[37] As

Figure 3. Kenda Conley et al., (*Storm Drainage Retention 2019*)

all waterways are connected, these freshwater bodies of water are eventually carried into brackish and marine water along with any pollutants or contaminants. Another factor that is adding to this type of pollution occurs during storm surges when water in CSO systems bypass wastewater treatment plants. Microplastics can be filtered through wastewater treatment systems by about 75-99%,[38] however, during a storm surge, water that may have been treated and purified of these contaminants completely bypasses the system. Instead, this water and the contaminants it contains are released into waterways.

A surprising source of microplastics is actually found within our homes and is exacerbated by an everyday chore: laundry. With the rise of synthetic fabrics to create new clothes every season, there is now a huge amount of clothes made out of small fibers of plastic such as nylon, polyester, and rayon. During the process of washing, small fibers break off from fabrics and are drained out with waste water which is eventually drained out to our oceans. As all water systems are connected, a piece of plastic that is flushed down the drain in upstate New York can eventually make its way south to New York City and travel from the bay into the Atlantic Ocean and anywhere beyond.

Poor urban planning and a lack of accountability has caused New York City to have to deal with this huge issue of polluted waters due to Combined Sewer Overflows and just an

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[37]Fan Liu, Alvise Vianello, and Jes Vollertsen, “Retention of Microplastics in Sediments of Urban and Highway Stormwater Retention Ponds,” *Environmental Pollution* 255 (2019): p. 113335, https://doi.org/10.1016/j.envpol.2019.113335, 1.

[38] Kenda Conley et al., “Wastewater Treatment Plants as a Source of Microplastics to an Urban Estuary: Removal Efficiencies and Loading per Capita over One Year,” *Water Research X* 3 (2019): p. 100030, https://doi.org/10.1016/j.wroa.2019.100030, 1.

overall archaic plumbing system. The city's Department of Environmental Protection (DEP), as with most issues regarding the environment, has done very little to address this issue let alone secure funds and policies that would incentivize both public and private sectors of the city to invest in programs that would ensure the protection of our waterways and also prevent further issues like this from arising. However, the city has been slow to bring about initiatives that provide substantial change and even the Department of Environmental Protection has proposed programs that are completely at odds with environmental advocacy. The program in particular that caused outrage is one where city officials proposed a plan in which wastewater would be disinfected with chlorine within the pipes before being discharged into one of three freshwater systems: Alley Creek and Flushing Creek in Queens and the Hutchinson River in the Bronx.[39] The problem with this program is that it only addresses the issue of storm water surges after the system has been overwhelmed and also would only resolve the issue of bacterial contamination while doing nothing for other types of pollutants.[40] Essentially, this plan is one that is barely a temporary solution- it does not even begin to address the real issue at hand of water pollution faced by the aquatic environments of NYC.

However, there are several initiatives (supported by many environmental advocacy groups) that New York City could take to mitigate the problem such as investing in "green infrastructure." Green infrastructure is a term that refers to a series of networks, practices, and spaces that mimic natural systems and provide a wide range of ecosystem services. Examples include but are not limited to: green roofs, rain gardens (aka street trees), and permeable

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[39]Corey Kilgannon, "New York Plan to Dump Chlorine Into Sewers Worries Environmental Advocates," The New York Times (The New York Times, May 1, 2017), https://www.nytimes.com/2017/05/01/nyregion/new-york-chlorine-sewers-environment.html, 1.
[40] ibid

surfaces/pavement.[41] The main objective in all of these infrastructure proposals is to remediate the threat that impervious surfaces, which are so prominent in cities like New York, have on the aquatic environment that surrounds the city. With the implementation of green infrastructure, surfaces are able to absorb rainfall and therefore prevent storm water surges from occurring, thus allowing for all water to be treated properly. It also prevents urban-runoff, and therefore pollutant debris from ending up in water systems, by decreasing the volume of water that streams on pavements during rainfall. In fact, if implemented properly, rain gardens alone have the potential to decrease CSOs by 13,170 gallons.[42] While the dangers CSO proposes to the health of NYC waterways are extreme, these initiatives can effectively mitigate them and protect these aquatic environments.

Chapter 3: An Environmental Health Crisis

Environmental health is an area within the public health sphere that focuses primarily on the relationships people have between themselves and their environment. This includes but is not limited to: the monitoring or mitigation of factors in the environment that affect human health and the study of people within natural and built environments. Pollution is one of the greatest threats plaguing humanity today and it is estimated that 6.5 million people die per year globally by air pollution **alone.**[43]

Microplastics are a huge concern as they have infiltrated our sources of water, food and have made their way into even our own bloodstreams.

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[41]"Green Infrastructure," Green Infrastructure - DEP, accessed December 24, 2020, https://www1.nyc.gov/site/dep/water/green-infrastructure.page.

[42] Social Ink, "Combined Sewage Overflows (CSOs)," Riverkeeper, October 27, 2016, https://www.riverkeeper.org/campaigns/stop-polluters/sewage-contamination/cso/, 1.

[43] "Air Pollution." World Health Organization. World Health Organization. Accessed December 24, 2020. https://www.who.int/health-topics/air-pollution.

Plastic pollution from large debris, macroplastics, are known to be detrimental to the health of both animals and humans alike. As previously mentioned, animals have been known to mistake plastics as a source of food. Besides the physical damage caused by plastic consumption there is also a risk of chemicals from plastics that can contaminate surrounding water (or water which is contained within a plastic container), soil, and air.

Plastics have the potential to be harmful to human health. For example, plastics have polluted sources of drinking and fishing waters thereby creating an environment of unclean drinking water and contaminated sources of food. Therefore, microplastics are also a public health concern as they are a by-product of plastic pollution and are essentially just plastics on a smaller scale.

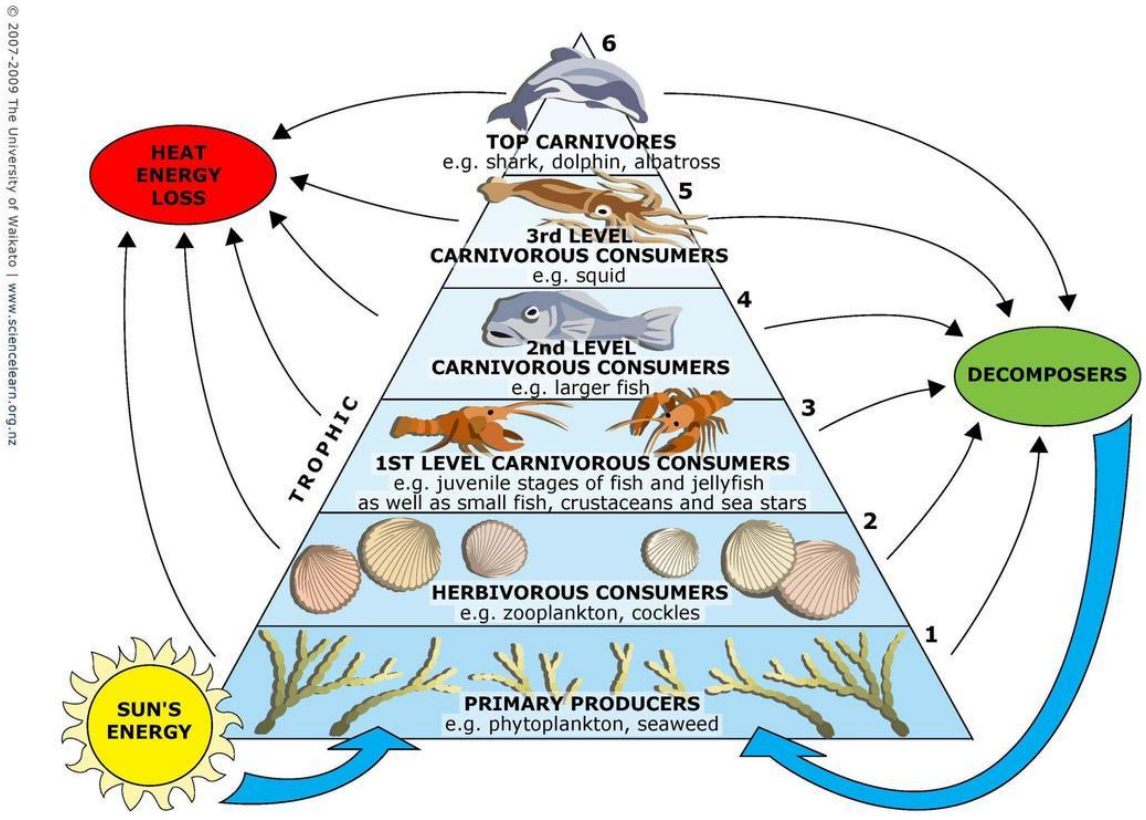
There is little research done on the effects of microplastics on the human body. a limited study conducted by the World Health Organization concluded that "there is insufficient information to draw firm conclusions on the toxicity of plastic particles and particularly the nano size particles, no reliable information suggests it is a concern."[44] That being said, there is very limited research that has been conducted on the effects of microplastics in the human body but despite that it is obvious that any foreign substance that is contaminating our bodies is concerning. Additionally, other studies conducted have suggested that microplastics have the potential to be toxic due to chemicals associated with manufacturing of plastics as well as chemicals that can be absorbed by plastics from the surrounding environment. Therefore, it can be said that the question of whether or not microplastics are a huge health concern is dependent on the amount of microplastics present and not whether plastic itself is toxic. Additionally, while current research does not show

[44] "Information Sheet: Microplastics in Drinking-Water." World Health Organization. World Health Organization, August 26, 2019. https://www.who.int/water_sanitation_health/water-quality/guidelines/microplastics-in-dw-information-sheet/en/.

conclusive evidence that microplastics are harmful in a way that can prove to be fatal to humans, there is research that suggests toxicity in animals.[45] Considering this, it can be assumed that microplastics are toxic to humans as well.

There are several ways in which plastics can enter someone's body. The most common ways are through consumption of food, water and inhalation

Figure 4. *Trophic Level Pyramid* (University of Wasako 2007)



[45] Koelmans AA;Mohamed Nor NH;Hermsen E;Kooi M;Mintenig SM;De France J; "Microplastics in Freshwaters and Drinking Water: Critical Review and Assessment of Data Quality." Water research. U.S. National Library of Medicine. Accessed November 21, 2020. https://pubmed.ncbi.nlm.nih.gov/30861380/.

Plastics Through the Food Chain. Via food is another way that microplastics can find their way into our bodies through a process called "bioaccumulation." Microplastics can be passed from animal to animal through the food chain within an ecosystem. In ecology, a food chain can be defined as a series of transfers of matter and energy from one source to another through food. Food chains are hierarchical and begin with small producer organisms and end with larger apex predators. Trophic levels are the consecutive levels in a food chain that show how energy is transferred, which can be visualized in figure 4.

Therefore bioaccumulation occurs when an organism with microplastics in its body is eaten by another organism and then the predator accumulates the prey's microplastics within their own body- more specifically adipose tissue. Bioaccumulation of plastics has been found to occur in organisms such as benthic macroinvertebrates, animals that live on the bottom of water systems and are exposed to plastic that has been embedded into the ground or seafloor. The process by which plastic enters waterways and can reach the seafloor is explained in Chapter 1.

Plastics in Our Food. Fish is a widely available source of food that is found all over the world and can be sourced from either freshwater or marine sources. Global fish consumption per capita has increased steadily over the years due to fisheries and aquaculture. It is estimated that "The increased production of fisheries and aquaculture products has resulted in increased global per capita consumption. In 2013, fishery products represented around 17 percent of animal protein intake by the world's population.[46]

Unfortunately for humans, this means that a widely available source of food is now contaminated with microplastic, or sometimes even macroplastic, pollution. According to the EPA,

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[46] Lusher, Amy L., and Natalie A. C. Welden. "Microplastic Impacts in Fisheries and Aquaculture." *Handbook of Microplastics in the Environment*, 2020, 1-28. doi:10.1007/978-3-030-10618-8_30-1.

“It has been estimated that plastic marine debris adversely affects at least 267 species globally, including 86% of sea turtles, 44% of seabirds, and 43% of marine mammals. The most common threats to wildlife include both physical hazards from ingestion and entanglement, and toxicological threats from ingestion of contaminants attached to and trapped within plastic particles. EPA's Clean Water Act and Superfund (CERCLA) programs have tools we can use to reduce the threats from these contaminants.”[47]

Plastics in Water. Bottled water is actually found to have higher amounts of microplastics than bottled water. However, it must be noted that people who do not have reliable sources or access to clean water may have to completely rely on bottled water. This water-bottle dependency paradoxically increases their exposure to microplastics while trying to prevent their exposure to unclean sources of water which may contain other pollutants or bacteria.

Microplastics and its effects on the human body

The question remains as to what microplastic contamination does to the human body, the health risks, and the implications that come with this phenomenon. Microplastic pollution can affect the body in both physical and chemical manners. Physically, a plastic particle may cut, be absorbed, or be embedded into tissues and organs whereas chemically, a buildup of contaminants may cause reactions or toxicity within the body.

The size of the plastic particle may have varying effects on the human body. Studies have found large pieces of plastic in feces, suggesting that microplastics may leave the body through excrement. However, studies have shown that larger pieces of plastic found in the stomach of marine life have contributed to the animal starving to death as the plastic created a blockage in their system or confused the animal’s gut into thinking they were not hungry and therefore

[47] “Impacts of Mismanaged Trash.” EPA. Environmental Protection Agency, July 30, 2020. https://www.epa.gov/trash-free-waters/impacts-mismanaged-trash.

slowly starving to death. In other cases larger, more angular pieces of plastic in marine life have torn through organs such as the esophagus, stomach, and intestinal wall and lining. Nanoplastics are a smaller form of microplastics that are usually defined as a fragment smaller than 1 mm to 1μm. Not all microplastics are nanoplastics; however, all nanoplastics are microplastics. Nanoplastics have the same potential of harm as larger microplastics such as the ability to bioaccumulate and possibly become toxic to the organism in which they reside. Like larger plastic pieces, there is a concern to what nanoplastics may do to organs and tissues within the body which can be seen here, "In contrast to microplastics, the epithelium of the gut wall does not form an impenetrable barrier to nanoparticles. Therefore, a special concern regarding nanoparticles is their ability to translocate across the gut epithelium, resulting in systemic exposure. However, most of the uptake data have been obtained with a large variety of nanoparticles, and not specifically with nanoplastics."[48] As more research is conducted, it can be hypothesized in the meantime that the size of the plastic particle may determine how the plastic may harm the body.

The health risks associated with chemical poisoning is also not well researched for microplastics. However, there is a concern that if a high enough bioaccumulation of microplastics can occur within a body then there is a possibility for chemical poisoning. Microplastics usually can contain two types of chemicals: additives and polymeric raw materials or from chemicals adsorbed/absorbed from the surrounding contaminated environment.

Chapter 4: History of the Bronx River

[48] "Impacts of Mismanaged Trash." EPA. Environmental Protection Agency, July 30, 2020. https://www.epa.gov/trash-free-waters/impacts-mismanaged-trash.

The Bronx to some is a scary, unfamiliar place full of garbage and crime. However, these horrible stereotypes hold no weight and to natives and visitors it is a beautiful, vibrant borough with the most green space in all of New York City. That being said, The Bronx has suffered from many socioeconomic issues and high rates of poverty and disease from pollution. It is home to a large number of immigrants mainly from the Caribbean, South America, and Africa.
The Bronx is one of the 5 boroughs in New York City and the only to be connected to the mainland of New York State. Notorious in the past for crime, poverty, and corruption it is also the birthplace of hip-hop, cultural icons from Tommy Hiliger to Cardi B, and is home to many iconic NYC sights. It is a historically socioeconomically disadvantaged area, however the egregious stereotypes that plague the Bronx hold no weight as it is a beautiful, vibrant borough home to the most green space in all of New York City.

The Bronx river was once a sacred source of life for the indigenous Lenape people and later the Dutch colonizers that settled on and around the river for fur trading. In fact, the river was so revered that the borough itself was actually named after the river- not vice versa. However, while once a source of clean freshwater and an oasis of wildlife, it became polluted with the onset of the Industrial Revolution. At the start of the nineteenth century, the implementation of industrial mills along the shore of the Bronx River served as a significant source of pollution as “lead, cyanide, bleaching products etc., as well as human excrement was rapidly finding its way into the river.”[49] The copious amounts of waste being poured into the river created an environment in which the ecosystems became overwhelmed and were unable to degrade these chemicals at a rate faster than consumption.

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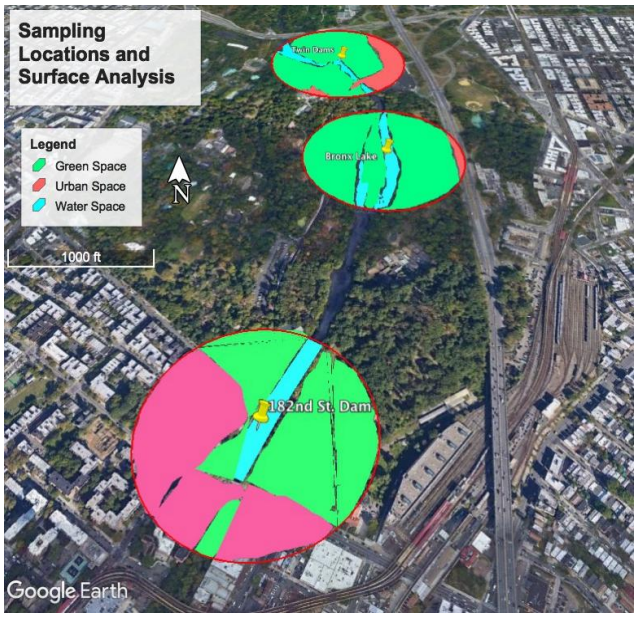
[49] Bellapigna, Zoe L., "A Historical, Political and Social Look into the Problem of Floatable Pollution in NYC's Bronx River" (2018). *Student Theses 2015-Present*. 71. https://research.library.fordham.edu/environ_2015/71

The urbanization of the Bronx in the late 1800s-early 1900s along the river also became a contributing factor to the river's degradation. [50] Today, the Bronx River is surrounded by a multitude of highways, marked by the legacy of the controversial Robert Moses, as well as the waste of countless businesses, households, and other components of urbanized areas. Efforts to restore the river to its former glory has largely been pushed by the Bronx River Alliance- a non-profit organization dedicated to educating the masses about the history and valuable ecosystem service that the river provides. In conjunction with the Bronx zoo (as the Bronx River runs through the zoo which preserves relatively untouched land for wildlife), Project TRUE is an internship program that has had several projects in the past dedicated to ecological restoration and research of the Bronx River. I conducted research through the Project TRUE program regarding microplastic pollution in the Bronx River that confirmed the presence of microplastics not only in the waters of the Bronx River but was also found in benthic macroinvertebrates. As seen in figures 4 and 5 there is a clear correlation between the amount of microplastics found in sample water and the location of where the sample was taken. The data presented showed a clear presence of plastic pollution throughout the Bronx River. All three sites (Twin dams, Bronx Lake, and 182nd St) demonstrated a presence of microplastics seen in water samples collected.

[50] de Kadt, Maarten. The Bronx River: An Environmental and Social History. The History Press, 2011.

Figure 5. Colon, *Sampling Locations and Surface Analysis* (WCS 2019)



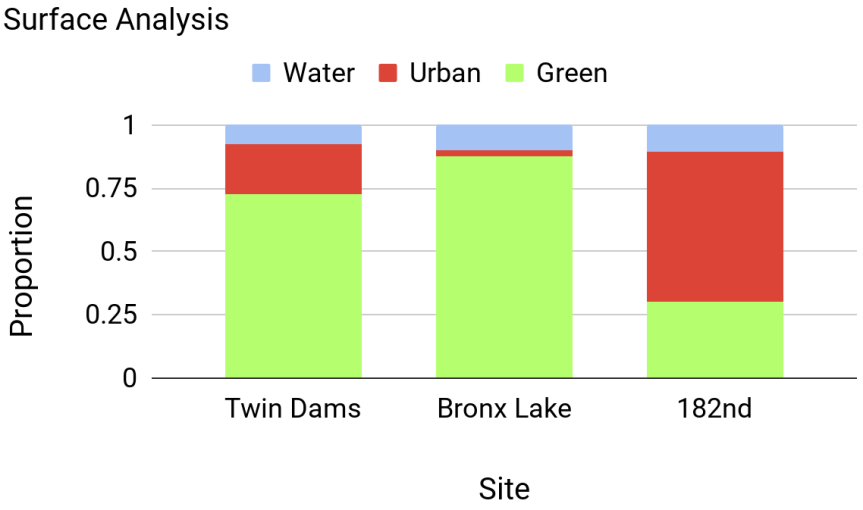


Figure 6. Colon, *Surface Analysis* (WCS 2019)

Chapter 5 : Where Do we Go From Here?

Plastic has touched more places on this planet than even oxygen has; it is everywhere and anywhere from the deepest depths of the oceans to the highest mountains to even the inside of a mother's placenta as she carries her unborn child. Without plastics we would live in a completely different world void of life-saving medical inventions, computers, and a limitless plethora of other items. The food we consumed would be different and even military victories may differ due to changes in technological warfare.Nevertheless, if climate change alone does not wipe out humanity, plastic pollution surely will. The plastic dilemma is overwhelming at best and utterly devastating with no hope at its worst. As scientists, environmentalists, and anyone who cares

about this planet fight to combat the oil and plastics industry, it is becoming increasingly obvious that no amount of recycling is going to solve this problem. The sheer degree of the plastics crisis may be beyond the scope of any solution. However, there are ways humanity can work together to create a cleaner, safer world without any more plastic consumption.

Government. To stop this crisis, I recommend complete and total abolition of plastics, plastic by-products, and other materials that are 1.) petroleum based and/or 2.) non-biodegradable. While this may seem like an extremely radical position to take, it is an approach that must be taken as plastics must be phased out of our lives and environment if we wish to have clean air, water, and soil in our lifetimes or even 1,000 years beyond. This is particularly imminent if there is no technology made in the near future that has the capability *and* capacity to fully degrade plastics out of our environment. As seen in chapter 1, the plastics crisis is completely out of control and is made worse by the fact that oil companies lobby to protect their own economic interests which are directly against the good of the environment. While some single-use plastics are necessary for current standards of living such as maintaining high quality health care, sanitation, and many scientific research items such as pipettes, there are still alternatives to traditional fossil-fuel based plastics I recommend that there is a radical change within the government where they lobby for the interests of the people and not of their own capitalist gain. One way to do this would be 1.) abolishing private energy and oil companies 2.) complete and total shift to renewable energy owned by the public sector.

Government: Carbon Tax

One policy that has already been implemented with varying success is the "carbon tax"- a fee that is applied whenever a fossil fuel enters into the economy primarily being large companies and corporations. A carbon tax is essentially a "cap and trade" system in which the

government sets a limit on emissions and issues a quantity of emission allowances(basically a set limit for the right to pollute) consistent with that cap.[51] Due to the fact that industries cannot 1.) exceed these emission allowances and 2.) must pay a fee for any and all carbon emissions or submission of fossil fuels into the economy, a carbon tax is therefore a tantalizing incentive for companies to transition to clean energy.[52] As mentioned previously, plastics are manufactured through the use of petroleum oil which emits carbon, and therefore greenhouse gases, into the environment. With the usage of a carbon tax, businesses would have the incentive to look for alternatives to energy sources to offset their carbon emissions in order to limit costs. Through this trickle-down effect, it could be hypothesized that a carbon tax would also effectively reduce the production of plastics and therefore a decrease in pollution.

[51] "Cap and Trade Basics." Center for Climate and Energy Solutions. April 16, 2021. https://www.c2es.org/content/cap-and-trade-basics/.
[52] ibid

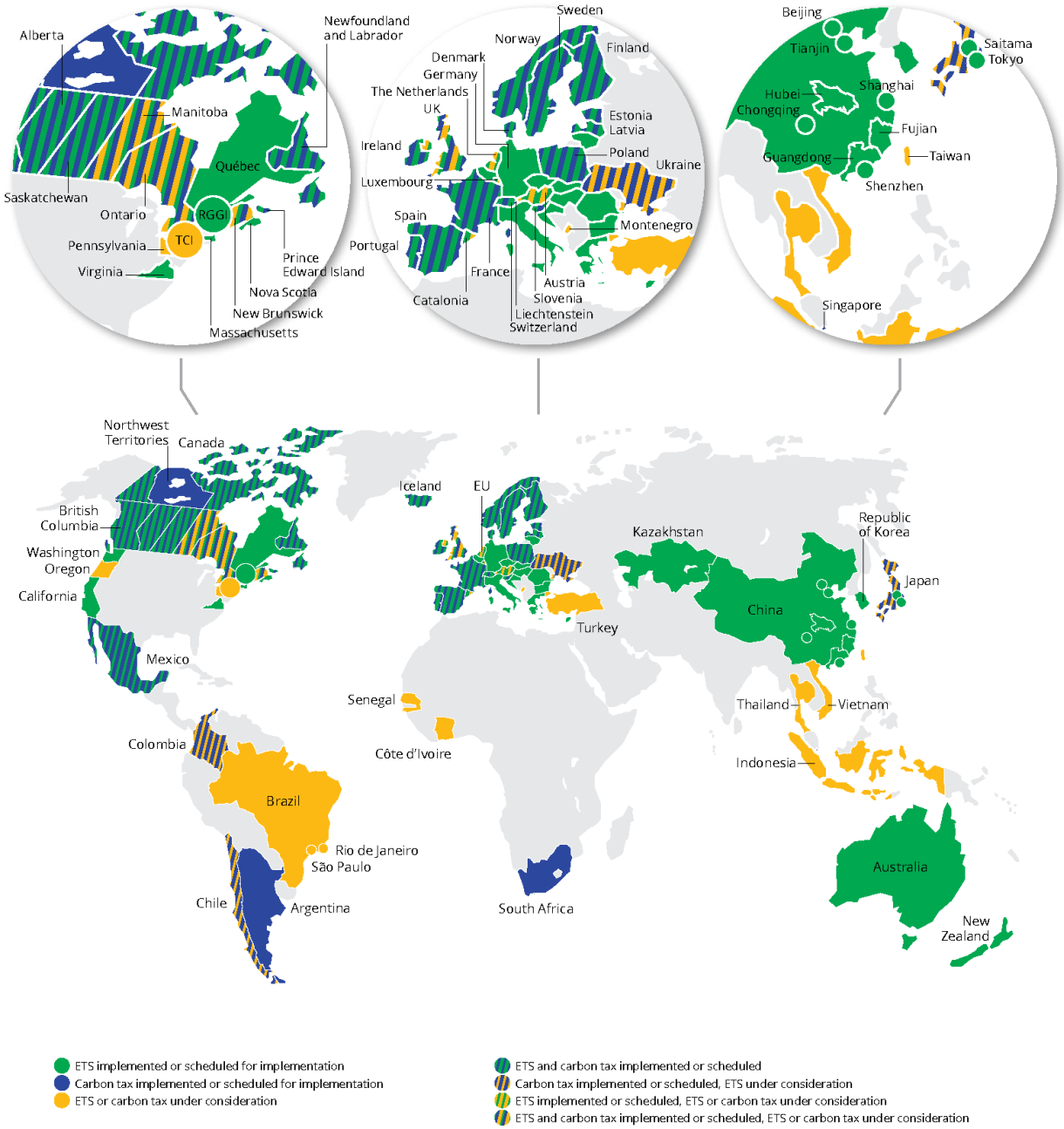


Figure 7.*Cap and Trade Basics. (*Center for Climate and Energy Solutions 2021)

As seen in figure7, many countries have already implemented a carbon tax or some variation thereof. The policies aforementioned then, would not be far-reaching as an effective

manner of handling and reducing the plastic crisis. This policy recommendation may be seen as radical- until it is entirely too late- however there is no act more radical or important than to save our environment.

Design.

It is often said there is no ethical consumption under capitalism. While that sentiment may be true, as of right now we still live in a capitalist, consumer driven society. If we are to consume, then my recommendation is that we consume products that are biodegradable, non-plastic, and as sustainable as possible. This could mean anything from simple changes like using bamboo toothbrushes and metal straws to a complete change of lifestyle based on sustainability, such as that adopted by zero-waste activists.[53] Plastic is used in almost every aspect of our life whether we realize it or not. The reliance on the convenience of plastic is not the individual's fault and is in large part pushed by major corporations. However, corporations also share a planet with us and through new technological design, there could be new areas of business that invest completely into replacing plastic products and therefore displacing our reliance on them. An example of this can be seen in zero-waste grocery stores, which gives a flashback to before plastic was widely utilized, that rely mainly on cardboard, glass, and biodegradable "plastics" for packaging and storage. Bags made out of cassava root strongly resemble the quality and hold of normal plastic bags but dissolve. Plastics are currently a necessity in certain industries such as the medical field. The invention of bioplastics however gives promising results from organic materials with similar properties to oil-based plastics but of course due to their organic nature- are biodegradable.

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[53] Sanderine van Odijk & Anne Poggenpohl, "Going Plastic Free: What Does a Zero Waste Future Look Like?," Greenpeace USA, November 7, 2019, https://www.greenpeace.org/usa/zero-waste-future/, 1.

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